“FUNCTIONAL OUTCOME ANALYSIS OF ILIZAROV RING FIXATOR AS DEFINITIVE FIXATION OF OPEN TIBIAL FRACTURES”

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CERTIFICATE

This is to certify that this dissertation titled **"FUNCTIONAL OUTCOME ANALYSIS OF ILIZAROV RING FIXATOR AS DEFINITIVE FIXATION OF OPEN TIBIAL FRACTURES"** is a Bonafide record of work done by **Dr.DURAISAMY EZHILMARAN**, during the period of his postgraduate study from August 2013 to August 2015 under guidance and supervision in the Department of Orthopaedics,Govt.Royapettah hospital and Govt.Kilpauk Medical College Chennai-10.,inpartial fulfillment of the requirement for M.S.Orthopaedic Surgery degree examination of The TamilnaduDr.M.G.R. Medical University to be held in April 2016.

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DECLARATION

I declare that this dissertation entitled "**FUNCTIONAL OUTCOME ANALYSIS OF ILIZAROV RING FIXATOR AS DEFINITIVE FIXATION OF OPEN TIBIAL FRACTURES"** submitted by me for the degree of M.S. is the record of work carried out by me during the period of August 2013 to August2015 under the guidance of **Prof. S.Anbazhagan, M.S. Ortho., D. Ortho,** Professor, Department of Orthopaedics, Govt. Royapettah hospital and Govt. Kilpauk Medical College,Chennai.This Dissertationis submitted to **The Tamilnadu Dr.M.G.R. Medical University**, Chennai, in partial fulfillment of the University regulations for the award of degree of M.S.ORTHOPAEDICS (BRANCH-II) examination to be held in April 2016.

Place: Chennai
Date: 30/9/2015

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CONTENTS

INTRODUCTION

INTRODUCTION

The most common long bone fractured is the tibia because of its location and less soft tissue coverage open fractures are more common in tibia than any other bone, in India where industrial safety norms are not followed and traffic rules are very poor. Because of that increasing road traffic accident the level of open tibia fractures incidence are so high.

Complications of Open tibial fractures often develop because of infection, inappropriate mechanical and biological environment, the usually confronted complications are combination of infection,

Nonunion, Malunion bone and soft tissue loss.

The treatment modality, outcome and prognosis are highly depends on the amount of soft tissue loss and injury, severity of the injury, degree of Communition, fragments displacements, mode of injury, amount of bone loss.

Ideal management of Open tibial fracture remains controversial.

To restore of optimum function modern day management is fully focused on through wound debridement and immediate stabilization and tissue protection

Various modality of treatment

1) Conservative management with traction or casting

2) External fixation

1) AO external fixator

2) Hybrid External fixator

3)Rail External fixator

3) Interlocking Intra medullary nailing

4) Plate Osteo synthesis

Various modality of treatment has various advantages and disadvantages, In India like developing countries where patient present late to the hospital and all proper facilities not always available for Early management, so usually Open Tibial fractures are managed with AO External Fixator, it lead on to high failure rate because of early pin loosening and not provide good Stability. Because this made us to look to the Ilizarov ring fixator is an alternative Option for management of Open tibial fractures

Most often Ilizarov Ring fixator has been reserved as a bail out option for complications arising out of open tibial fractures, we have used Ilizarov Ring Fixator as a Primary modality of treatment in treating open tibial fractures.

Our study is to enlighten the important role of Ilizarov ring fixator for Grossly communited open tibial fractures. It is a method of minimally invasiveexternal fixation system using small diameter transosseous Ilizarov wires which Are tensioned and fixed to circular rings and rods, Ilizarov ring fixator provides good stable fixation in multidirectional and multiplane and it facilitate the cyclic micro motion at the fracture site for bone healing, Various modality of treatment exist at present, but these methods are results in many complication for open tibial fractures with contamination, Boneloss,Infection ,Soft tissue

injuries.Ilizarov ring fixator is the ideal management for open metaphyseal,open diaphysis highly contaminated open tibial fractures with severe soft tissue injuries with poly trauma.

AIM OF OUR STUDY

AIMS AND OBJECTIVES

1) To Evaluate 25 cases of open tibial fracture which have been treated with Ilizarov Ring Fixator as per fracture pattern

2) To Analyse the functional outcome following definitive fixation of these injuries using Tucker’s criteria

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The management of open tibial injuries gradually evolved due to,

1) Better understanding of surgical and functional anatomy and biomechanics of the tibia.
2) Identification and treatment of associated injuries.
3) The advent of External fixation devices.
4) Advancement in neurovascular surgery.
5) Aggressive soft tissue management.

In 2010 Naveed Wani reported series of Sixty patients (51 males, nine females; age range 20–62 years with mean age 32.8 years) with type II (11 patients), type IIIA (13) and type IIIB (36) tibial diaphyseal fractures underwent emergency debridement and minimal bone fixation (with external fixator), followed by definite fixation with the IEF after three to five days. He concluded that All fractures united with an average union time of 21.1 weeks (standard deviation [SD] 3.18) in type II, 21.7 weeks (SD 3.57) in IIIA and 24. 9 weeks (SD5.14) in IIIB fractures. The best results will be achieved by Early application of the Ilizarov fixator constitutes an excellent management of open tibial fractures, especially types II, IIIA and IIIB, due to good functional and radiological results. Despite the technical difficulties and some complications (which are mostly minor)IEF may be the preferred method in open tibial fractures, especially types II and III

In 1992,Schwartsman reported about 18 tibial fractures were treated using the Ilizarov method and apparatus. Injuries included four closed fractures and 14

open fractures, There were three Grade I open, four Grade II open, and seven Grade III open tibial fractures,in all these patient The average time from application of the device to complete fracture healing was 5.6 months, with a range of 3.25 to 13 months, his results indicate that the Ilizarov method is indeed a useful adjunct in the orthopedic armamentarium for the treatment of either open or closed tibial fractures. No practical contraindications to the use of the Ilizarov device in the management of tibial fractures were encountered.

In 2003 G. Hosny reported about 34 open tibial diaphyseal fractures,all the cases was debrided and the bone fixed with Ilizarov device. Out of 34 patient 30 patients were available for evaluation with a mean follow-up after fracture union of 40.5 (24–80) months. He encountered Two fractures were grade I, 16 grade II, six grade IIIA, five grade IIIB and one grade IIIC. Where ever soft tissue cover needed ,the Soft-tissue healing was achieved through split-thickness skin grafting, pedicle flaps and Z-plasty, delayed primary closure, , he stated that all fractures were united with an average 5.6 (3–15.4) months. He described 28 patients had excellent and good functional outcome, one was fair and one was had poor outcome, he conclusion was Despite numerous complications arises with the use of Ilizarov external fixator but it provides definitive fracture stability .

Matt D. A. Fletcher reported that Accepted management of diaphyseal fractures associated with significant tissue loss is rigid intramedullary stabilisation with free or rotational musculocutaneous flap coverage. Circular external fixation is a powerful tool in the management of limb trauma and with

recent advances has been developed to provide multiple techniques for which even massive tissue loss can be addressed without the need for free tissue transfer. Gradual and acute shortening, acute fracture deformation and gradual lengthening with restoration of deformity combined with distraction tissue histiogenesis can provide the surgeon with an array of options which can be precisely tailored to the particular personality of a severe open diaphyseal fracture.

Ebrahim Hasankhani ,Mahamad Taghi Payvandi, Ali Birjandinejad did study between march 1999 and feb 2002. They treated 25 patients with complex open tibial fractures by using ilizarov ring fixator .**It include** IIIA, type IIIB , and type IIIC in 19, 9, and 4 patientsrespectively,there Conclusion was the Ilizarov ring external fixator is an effective a salvage procedure in the treatment of complex open tibial fractures and it allows for the simultaneous treatment of infection, ,bone loss, deformity. Non-union.

Muharrem Inan ,Mehmet Halici,Irfan Ayan,Mehmet Tuncel,Sinan Karaog lu, in their study they compared the radiographic results and clinical outcome of unreamedtibialNailing (UTN) and Ilizarov external fixation (IEF) for the treatment of type IIIA open fractures of the tibia,in this study they divided the 60 patients in to two groups, Thirty two of open type IIIA tibial shaft fractures were treated with an IEF and twenty nine with unreamed IL IM Nailing, The average time-to-bone healing was 19 weeks (range 14–23 weeks) for IEF and 21 weeks (range 16–36 weeks) for UTN; The results of the current study showed that IEF technique had a notable incidence of pin-tract infection, joint contracture, and

shorthening related to treatment of the delayed union. The UTN technique had the disadvantage of a posttraumatic osteomyelitis and delayed union requiring additional surgery. We believe that the decision to use IEF or UTN should be made on a case-by-case basis.

Robert Rozbruch reported series of Twenty-five patients with bone and soft-tissue defects associated with tibial fractures and nonunions. The average soft-tissue and bone defect after debridement was 10.1 (range, 2–25) cm and 6 (range, 2–14) cm respectively.it was treated by ilizarov ring fixator they also found that The Ilizarov method can be successfully used to reconstruct the leg with tibial bone loss and an accompanying soft-tissue defect. This limb salvage method can be used in patients who are not believed to be candidates for flap coverage. One also may consider using this technique to avoid the need for a flap. Gradual closure of the defect is accomplished resulting in bony union and soft-tissue closure.

ANATOMY

RELEVANT ANATOMY OF LEG

Tibia

The tibia is the main bone of the leg, forming what is more commonly known as the shin. Tibia expands at the proximal and distal ends and articulating at the **knee** and **ankle** joints respectively. Tibia is the second largest bone in the body; this is due to its function as a **weight bearing** structure. The bony landmarks of the tibia, the region anatomy, and look at any clinical correlations which are all most important for surgical approach.

Proximal

The proximal end of tibia is **widened** by the medial and lateral **condyles**, it aiding in weight bearing. The condyles form a flat surface, known as the **tibial plateau.** The tibial plateau structure articulates with the femoral condyles to form the major articulation of the knee joint. **Intercondylar eminance** isLocated between the condyles ,this consists of two tubercles and a roughened area. This area is the main site of attachment for the ligaments and the menisci of the knee joint. The tibial intercondylar eminence fit into the **intercondylar fossa** of the femur.

On the anterior surface of the proximal tibia, just inferior to the tibial plateau , the **tibial tuberosity** is situated. This is where the patella ligament attaches.

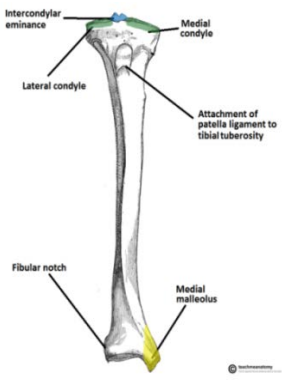
Shaft

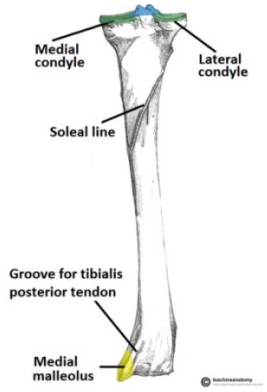
The tibal shaft has three borders and three surfaces; anterior, posterior and lateral. Anatomically and clinically important borders/surfaces are described here

Anterior border – The start of the anterior border is marked by the tibial tuberosity. It is palpable down the anterior surface of the leg as the shin. Here, the periosteal covering of the tibia is susceptible to damage, presenting clinically as bruising.

Posterior surface – This is marked by a ridge of bone called the soleal line. It runs infer medially, eventually blending with the medial border of the tibia. It is here where part of the soleus muscle originates

Lateral border – It also known as interosseus border. Interosseous membrane attached to this border and bind to both bones





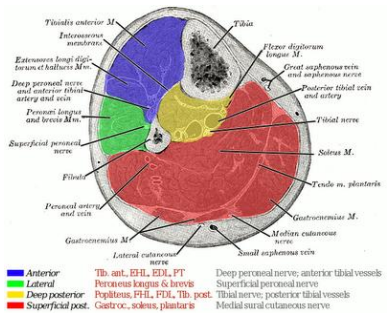


Fig.1 Anterior Surface. Fig.2 Posterior Surface Fig.3Cut Section

Distal

The distal end of the tibia also **widens** to help with weight bearing. On the medial side there is a bony projection continuing inferiorly– this is called the **medial malleolu**s. Medial malleolus articulates with the tarsal bones to form

part of the ankle joint. Tibialis posterior muscle attaches to the groove of the posterior surface of the tibia, .Laterally, on the distal end, there is a notch, where the fibula is bound to the tibia. It is known as the **fibular notch.**

Compartments of leg

Compartments: The leg is divided into four osseo fascial compartments by Interosseous membrane of the leg , Transverse intramuscular septum, Anterior intramuscular (crural) septum

Anterior compartment:

Muscular-Tibialis anterior , Extensor digitorum longus Extensor hallucis longus, Peroneus tertius, Neurovascular-Deep peroneal nerve, Ant.tibial artery and vein

Lateral compartment

Muscular- Peroneus brevis, Peroneus long us ,Neurovascular-Superficial peroneal nerve

Superficial posterior compartment

Muscular-Gastrocnemius muscle, Plantaris, Soleus muscle ,Neurovascular-Sural nerve

Deep posterior compartment

Muscular-Tibialis posterior, Flexor digitorum longus , Flexor hallucis longus, Popliteus ,Neurovascular-Tibial nerve, Posterior tibial artery and vein The anterior compartment muscles Collectively they act to **dorsiflex** and **invert** the foot at the ankle joint. The EHL and EDL will extend the toes. The muscles in this compartment are innervated by the **deep peroneal nerve** (L4-L5), and blood supply is provide by anterior tibial artery

Muscles in the posterior compartment of the leg

The posterior compartment of the leg contains seven muscles, it has organized in two layers,Superficial and deep. Fascia which separate the layers the compartment presents in the posterior aspect of leg, All the muscles in this areaof posterior leg act to plantarflex and invert the foot. They are innervated by the posterior tibial nerve, a terminal branch of the sciatic nerve.

Lateral compartment

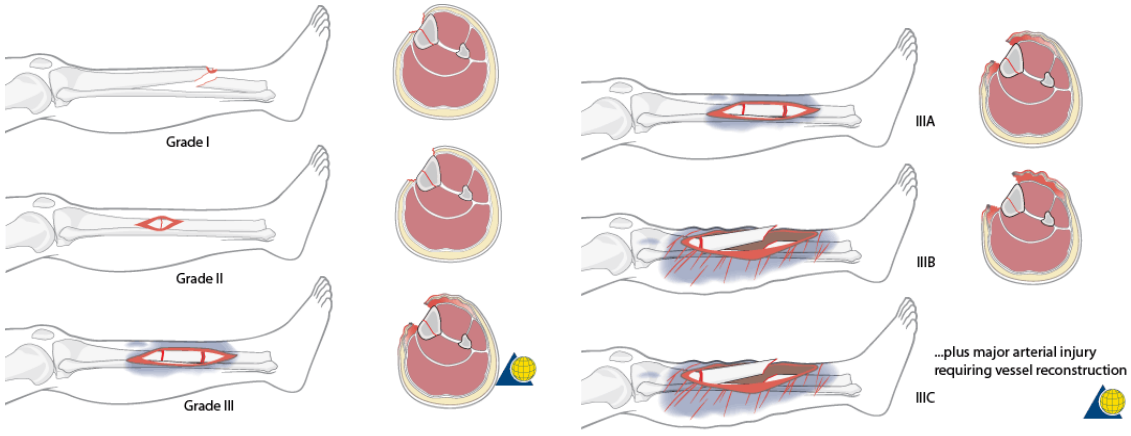
There are two muscles in the lateral compartment of the leg; **eversion** is the common anatomical function of the muscles. Only a few degrees of eversion is possible. The work of these muscles is to **fix** the medial margin of the foot during running, and preventing **excessive inversion**.

Classification of open tibial fractures

Evaluation is usually possible Only at the end of debridement.

Gustilo–Anderson classification :Table :1

Type	Wound	Level of Contamination	Soft Tissue Injury	Bone Injury
I	<1 cm	Clean	Minimal	Minimal Comminution
II	>1 cm-<10cm	Moderate	Without extensive /skin flaps/avulsions	Moderate comminution
III				
A	Usually >10 cm	High	Extensive but coverage of bone possible	Segmental/severlycommunited even wound with 1cm size
B	Usually >10 cm	High	Extensive but coverage of bone not possible Periosteal stripping	Moderate to severe comminution
C	Usually >10 cm	High	Very severe loss of coverage plus vascular injury requiring repair; may require soft tissue reconstructivesurgery	Moderate to severe comminution



TSCHERNE CLASSIFICATION OF OPEN SOFT-TISSUE INJURIES

Grade I

Skin is lacerated by a bone fragment from the inside.

- No or minimal contusion of the skin,
- Simple fractures are the result of indirect trauma

Grade II

- Skin laceration with a circumferential
- Skin or soft-tissue contusion
- Moderate contamination.
- Direct trauma .

Grade III:

- Extensive soft tissue damage,
- Major vessel and/ or nerve injury.
- Severe bone comminution belongs in this group.
- Farming accidents, high-velocity gunshot wounds,
- Compartment syndrome

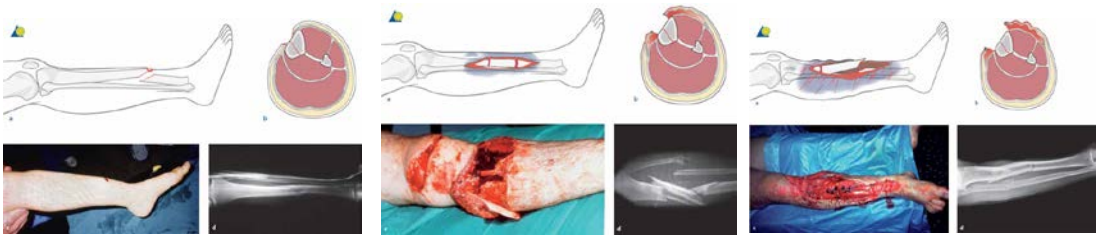
Grade IV

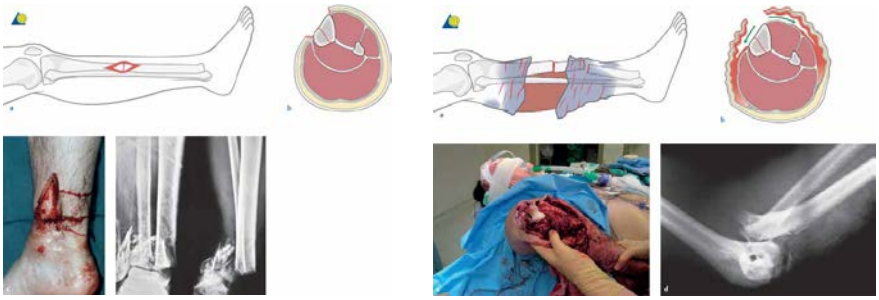
- Subtotal and total amputations.
- Subtotal amputations are defined

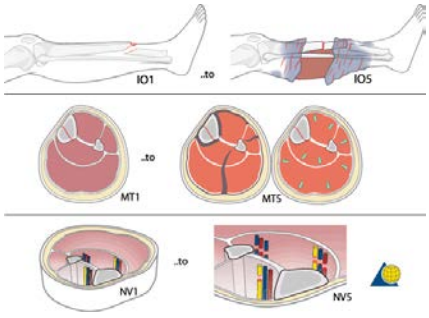
AO CLASSIFICATION OF OPEN TIBIAL FRACTURES

AO soft-tissue classification: Table -2

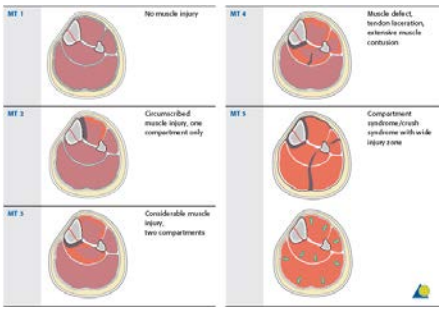
Open skin lesions (IO)	
IO 1	Skin breakage from inside out
IO 2	Skin breakage from outside in < 5 cm, Contused edges
IO 3	Skin breakage from outside in > 5 cm, Increased contusion, devitalized edges
IO 4	Considerable, Full-thickness contusion, Abrasion, Extensive Open degloving,Skin loss
IO 5	Extensive degloving

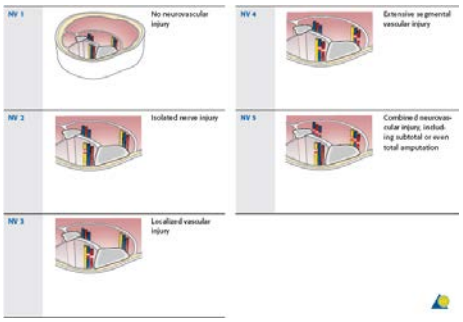






Muscle involvement **Neurovascular**





Ganga Hospital Open Injury Severity Score: Table -3

A high sensitivity and specificity for salvage in type IIIB injuries and which can predict clinical outcome

Covering structures: skin and		**Skeletal structures: bone and joints**	
Wounds without skin loss		Transverse/oblique fracture/butterfly	
Not over the fracture	1	Fragment <50% Circumference	1
Exposing the fracture	2	Large butterfly fragment >50% circumference	2
Wounds with skin loss		Comminution/segmental fractures without bone loss	3
Not over the fracture	3	Bone loss <4 cm	4
Over the fracture	4	Bone loss >4 cm	5
Circumferential wound with skin loss	5		

Functional tissues: musculo tendinous (MT) ***And nerve units***	
Partial injury to MT unit	1
Complete but repairable injury to MT units	2
Irreparable injury to MT units/partiall ossofacompartment/complete injury to posterior tibial nerve	3
Loss of one compartment of MT units	4
Loss of two or more compartments/subtotal amputation	5
Comorbid conditions: add 2 points for each Condition present	
Injury–debridement interval >12 hours	
Sewage or organic contamination/farmyard injuries	
Age >65 years	
Drug-dependent diabetes mellitus/cardiorespiratory	
Diseases leading to increased anaesthetic risk	
Polytrauma involving chest or abdomen with injury	
Severity score>25	
Fat embolism,Hypotension with systolic blood pressure <90 mmhg At presentation	
Another major injury to the same limb/compartment syndrome	

Outcome: Table -4

Total scores:	
Group 1	Scored less than 5;
Group II	6–10;
Group III	11–15:
Group IV	16 or more

Group IV group III - underwent amputation.

A threshold score of 14 -high sensitivity and specificity to predict amputation.

The score have better predictive rates than the Mangled Extremity Severity Score (MESS) for predicting amputation,

Table-5. AO Classification of Diaphyseal Fracture

Proximal Fracture

41-A1

41-A EXTRAARTICULAR FRACTUE

41A1 AVULSION

41-A2

41A2 METAPHYSEAL SIMPLE

41-A3

41A3 METAPHYSEAL MULTIFRAGMENTARY

41B PARTIAL ARTICULAR FRACTURE

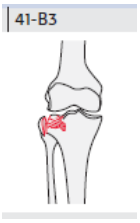
41-B1

41B1 PURE SPLIT

41-B2

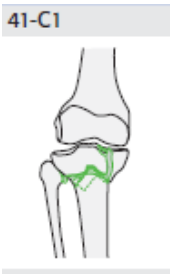
41B2 PURE DEPRESSION

41B3 SPLIT DEPRESSION



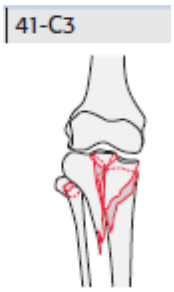
41C COMPLETE ARTICULAR FRACTURE

41C1 ARTICULAR SIMPLE METAPHYSEAL SIMPLE



41C2 ARTICULAR SIMPLE,METAPHYSEAL

MULTIFRAGMENTARY

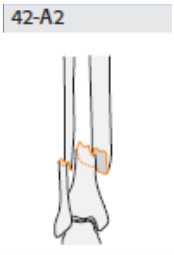


41C3 ARTICULAR MULTIFRAGMENTARY

DIAPHYSEAL FRACTURE

42A SIMPLE FRACTURE

42A1 SPIRAL



42A2 OBLIQUE

42A3 TRANSVERSE

42B WEDGEFRACTURE

42B1 SPIRAL

42B2 BENDING

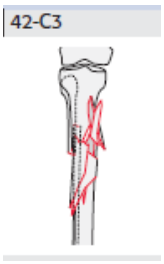
42B3 FRAGMENTED

42C COMPLEX FRACTURE

42C1 SPIRAL

42C2 SEGMENTED

42C3 IRREGULAR

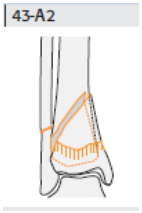


DISTAL FRACTURE

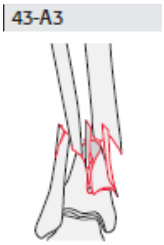
43A EXTRAARTICULAR#

43A1 SIMPLE

43A2 WEDGE

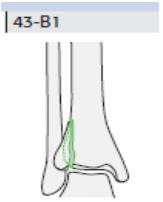


43A3 COMPLEX



43B PARTIAL ARTICULAR FRACTURE

43B1 PURE SPLIT

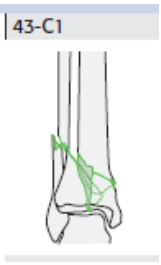


43B2 SPLIT DEPRESSION

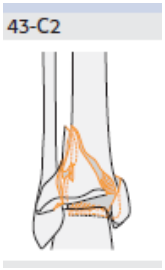
43B3 MULTIFRAGMENTARY DEPRESSION

COMPLETE ARTCULAR#

43C1 ARTICULAR SIMPLE ,METAPHYSEAL SIMPLE



43C2 ARTICULAR SIMPLE,METAPHYSEAL



43C3 ARTICULAR MULTIFRAGMENTARY

Table 6. Winquist and Hansen classification

This is based on fracture comminution ,it was used before for routine placement of statically locked IM nail,used for classify the communition in open tibial fracture.

Winquist and Hansen classification	
Type 1	Minimal or no comminution
Type 2	Cortices of both fragments at least 50% intact
Type 3	50% to 100% cortical comminution
Type 4	Circumferential comminution with no cortical contact

Table 7. The most common wire and pintract infections are classified by dahl et al.

Dahl et al classification

GRADE	**CHARACTER**	**TREATMENT**
GRADE 0	Pin site is normal other than marginal erythema	Weekly pin care
GRADE I	Marginal inflammation	Daily pin care
GRADE II	Inflamed pin site with serous discharge	Daily pin care with antibiotics
GRADE III	Inflamed pin site with purulent discharge	Daily pin care with antibiotics
GRADE IV	Osteolysis of near and far cortex	Pin removal with irrigation and antibiotics and care
GRADE V	Osteolysis of near and far cortex with sequestrum	Pin removal with irrigation and antibiotics and care with stabilize the construct

Table 8. Checketts and Otterburn's grading system

Grades Characteristics	Infection	Treatment
Grade-I	Slight discharge Improved pin site care,Redness around the pins	
Grade-II	Redness of the surrounding skin Improved pin site care, Pain and tenderness in the soft tissue, Discharge of pus.	Oral antibiotics
Grade-III	Similar To Grade-II Affected pin or pins resisted and external Fail to improve with intensive local fixation can be continued.	Treatment and antibiotics.
Grade-IV ·	Severe soft tissue involvement External fixation must be abandoned.Affecting more than one pin, Associated loosening of the pin	Daily pin care with antibiotics
Grade-V	Clinical appearance same as grade-iv External fixation must be abandoned, Bone involvement,Radiographs show osteomyelitis	Pin removal with irrigation and antibiotics and care
Grade VI	Sequestrumformation within the bone Curettage of the pin tract,A persistent sinus develops	Pin removal with irrigation and antibiotics and care with stabilize the construct

Grade I- III = Minor infections. Grade IV- VI = Major infections

MATERIALS AND METHODS

MATERIALS AND METHODS

Purpose of the study

1) To Analyze the functional outcome following fixation in open tibial fracture using Ilizarov ring fixator

2) To Study the influence of associated injuries in deciding the timing of definitive fixation.

Data collection and methods: collection of data as per the proforma with consent from the patients admitted in the Orthopaedic department, Govt.Royapettah hospital ,Kilpauk medical college , Chennai.

Inclusion criteria

- Patients in the age group of above 18 years
- Both male and female patients
- Patients with compound fractures of tibia
- Poly trauma patients with compound fractures of tibia
- Associated with neuro vascular injuries
- All grade of gustilo anderson classification (1 to 3c)
- Compound fractures of tibia < 7days
- Associated head injury
- All pattern of fractures of tibia

Exclusion criteria

- Age less than 18 years
- Pathological fractures

- Compound fracture >7 days
- Crush injuries
- Associated with Compartment syndrome

Methodology

All the trauma patient in the government Royapetth hospital AB casuality will be immediately initiated on ATLS protocol by using this airway,breathing,circulation are restored and maintained.in the emergency room blood pressure ,pulse rate and oxygen saturation (spo2) are seriallymonitored. Oncethe patient is stabilized thermodynamically search for any other injuries are present

Once patient is stabilized in emergency room the shifted to radiographs and appropriate xrays are taken, entire knee and leg with ankle joint are imaged with xrays.those patients are diagnosed of having fracture tibia with open injuries in the leg were immediately splinted with Above knee slab and proper dressing applied for the open wound,

The basic investigations like complete blood count ,renal function test,chestxray,ECG were done immediately. If any derangement in the hemodynamic status blood transfusion arrangement were made.

All open injuries were initially managed by giving through wound debridement in the emergency theatre,appropriate and prophylactic antibiotics were given before and after surgery. Tetanus toxoid vaccine was started. Depending upon the status of the wound and level of contamination, size of the wound external fixator were applied as a temporary fixation.

In patients undergoing external fixator as a tempory fixation were converted to definitive fixation with ilizarov ring fixator with 5 days of injury,after application of ilizarov ring fixator ,softtissue cover wa flap coves effectively given with flap cover or split skin graft.

In all Patients with open tibial fractures are categorized in to

1) Stable
2) borderline
3) unstable
4) in extremis

In all the stable and borderline patients who become stable after resuscitation were classified according to the gustilo Anderson classification for open injuries and their extremities splinted and temporary fixation was done

In all patients who are unstable and extremis patients the life threatening injuries managed immediately with damage control orthopaedics and managed in icu care until they become stable,In our study we only opted the patients who has been undergone ilizarov ring fixator as definitive fixation for open tibial fractures with in 5 days of injuries

The management plan for given patients was made according to the size of the wound ,grade of open fracture ,fracture pattern and location of fracture and the associated injuries

Once patients was stabilized with ilizarov ring fixator as definitive management,the patient was subjected for knee and ankle mobilization ,weight bearing with walker according to associated injuries and condition of the patient.

Serial follow up was made with AP and Lateral view x-rays were taken at 4 weeks ,6 weeks,3 months,6 months and one year for to know the bone union and functional outcome of patients were analyzed using tuckers criteria

Total of twenty eight patients were included in our study out of those patients we lost follow up of two patients and one patient undergone fixator removal during course of treatment because of poor compliance of patient and they were excluded from our study

Final study encomprises of 25 patients with open tibial fractures who were classified according to the Gustilo Anderson classification . All the stable patients and polytrauma patients undergoing emergency procedures and Damage control Orthopaedics were analysed with standard parameters as follows and taken up for definitive fixation once they satisfy all the criteria as follows,

- Stable hemodynamics (systolic b.p. > 100 mm hg diastolic b.p>70mmhg)
- Stable oxygen saturation at room temperature (spo2 92%) (
- Temperature should not be less than 32 degree c (t)
- No requirement of inotrophic support
- Urine output - > 1 ml /kg/hr (Bag monitoring/ i/o char
- Requirement of fluids (should not exceed 3l or 5 units of blood/24 hrs period (i Bg an No coagulation disturbances (normal bt/ct/platelet count> 1 lakh /cu.mm) (co H)

Implants and instruments

External fixator: External fixators are emergency and temporary stabilization device for open injuries and it is the valuable tool in damage control orthopaedics,in our study total number of emergency temporary external fixator was 15 cases out of 25 cases.external fixator was applied after through wound debridement,for distal most fracture of tibia we used t clamps .

AO external fixator :External fixator consist following implants which we used for our study

1) Ao clamp,2)Ao rod,3) 4.5 mm Schanz pin,4) 5.5 mm Schanz pin,5)tube to tube clamp6)t clamps In our study all open tibial fractures are taken to emergency theatre under proper anesthesia through wound debridement done which was followed by external fixator application in sequential manner. We only used normal saline for wound debridement ,strictly avoided the hydrogen peroxide and beta dine to protect the soft tissue and bone damage from them. Daily saline soaked dressing was made for all patients until soft tissue reconstruction was made.

Ilizarov ring fixator

The ilizarov ring fixator consist of various components:

- Rings and Arches, Ring Connections, Connectors
- Instrumentation:Wiretensioner,Wrenches,Wirebender,Wirecutter,drillbit,) handdrill, Electrical drill,

Rings and arches

The Ilizarov device is a circular external fixator the principal component is a ring with flat surface with multiple holes

Types of rings

Half rings,Complete full rings,Five eight rings,Half rings with curved ends,Arches

Half rings: Theilizarov apparatus contains 12 sizes of half rings.it measuresed in its internal diameter in millimeters,generaly used sizes for adult is 80,100,110,120,130,140,150,160,180,200,220,240mm,for paediatric patient 80 to 140mm sizes are generalyused.each hole diameter is 8mm and the distance between the hole s 4mm in diameter

Full rings: Full rings are slightly lighter than half rings and it has six more holes which can be used for different on purposes ,such as introduction of a connectd plate, a threaded rod or hinges.the full rings are difficult to remove if for some reason there is tissue swelling .

Five eight rings

Five eight rings mainly used near knee and ankle,

1) Provide more place for two cross wires
2) Soft tissue damage cases it is uses in the middle frame
3) My cutaneous flaps and large deep incisions as in compartment it is useful

Half rings with curved ends

These the modification of 5/8 rings with ends are curved outwards ,its mainly used in deltoid region, it is not so strong as full rings but three point connection to the adjacent rings permits it to bear necessary loading stresses.

1) Open fractures of tibia and femur

2) Proximal and Distal Humerus – Preserve elbow and shoulder motion

Ring connections : Bolts.,Nuts

Bolts:

Three sizes of bolts are available for fixing the half rings each other and rods to ring.

1) 10mm: Connecting half Pins,Sockets,Bushings and rods

2) 16mm:Connecting plates and posts

3) 30mm:Connecting three or more parts produce gap between two parts

Nuts:

Three variants of nuts are available for different uses.

A) 6mm thick nut is also known as full nut

B) 5mm thick nut is also known as ¾ nut

C) 3mm thick nut is also known as ½ nut

Connectors:

Wires,Rods,Slottedcannulatedrods,Telescoping rod with partially threaded shaft,Partially threaded rods,Graduated telescopic rod,Wires,Wire fixation bolts,Wire fixation buckles,Plates,Connecting plate with threaded end,Curvedplate,Threadedsockets,Bushings,Supportposts,Washers,Half hinges

Wires:

Wires are the main part of the ilizarovapparatus,wire placement is the crucial step and determine the treatment and final results.

Despite its unimpressive appearance ilizarov used the kirschner wire .

Advantages of k wire:

1) K wire damage very little soft tissue and compact bone and bone marrow
2) Because of its elasticity it dampens the vibration and prevent the soft tissue and bone destruction
3) Minimum external contamination because of its small diameter
4) Easy to remove and penetration holes are very small

Types of wires used by ilizarov

1) K- wire with point bayonet tip

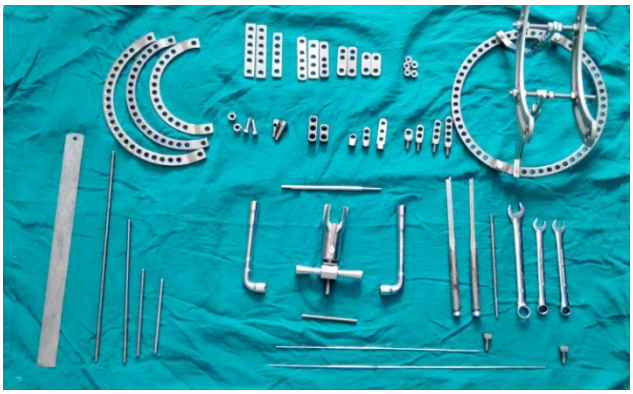
   Mainly used in cortical bone

2) K- wire with trochor tip

   Mainly used in cancellous bone

3) K- wire with bayonet tip with stopper

   Mainly used to hold the displaced bone fragments



Sizes:

1.8mm adult

1.5mm children

All types of wires made in Length: 300mm,370mm,400mm

Wire fixation bolts:

Botls are fixes the k wires on the flat surfaces of rings,it is 6 mm diameter at the head and 18mm diameter at threaedleg.commonly two types are used

1) Cannulated wire fixation bolt 2mm hole just below the bottom of head with this hole 0.5mm groove to accomadate k wire.

2) Slotted wire fixation bolt

Have a slott on the side on the base of head

Connecting rods:

Wire tensioner: Russian manual method

Ilizarov wire tensioner,Dynamometer

Patient positioning for Ilizarov ring fixator application

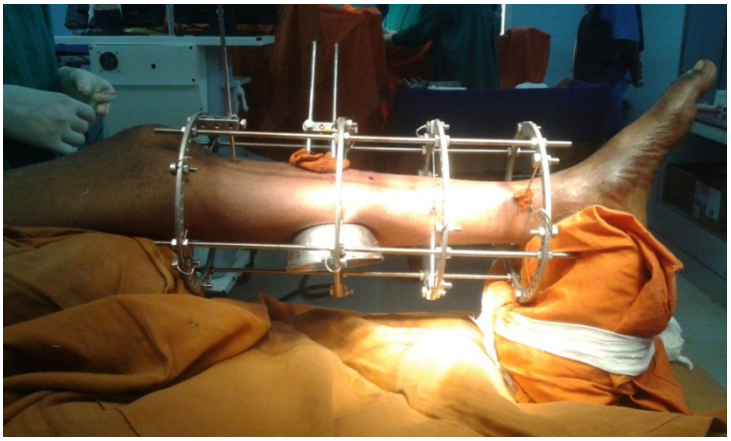


Figure-4

Patient was positioned in such a way that the other limb was just postions over the table.used two pillow was used for this kind limb position one placed under the thigh and one under the heel,we designed stand for position of the limb for applying ilizarov ring fixator instead of pillows it is more comfortable than the pillows.last 20 cases we used those stands.

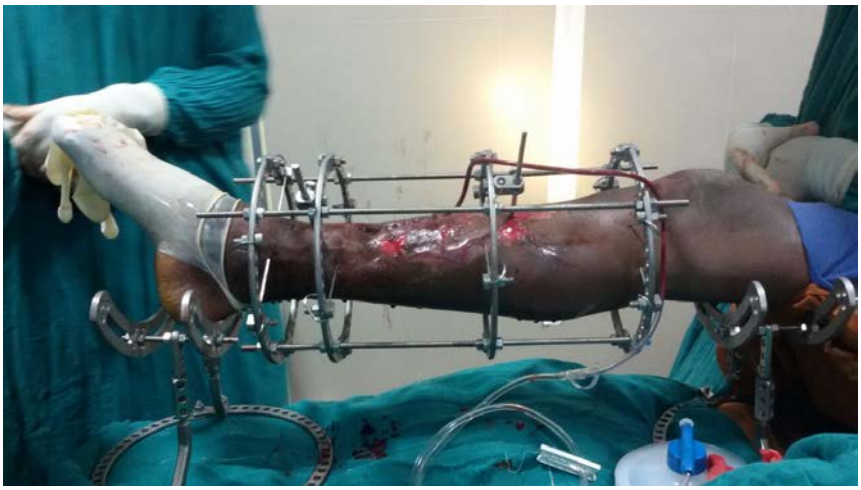


Figure-5

Biomechanics of Iilizarov method

The biomechanics ofilizarov are more or less based up on the biological law of the tissue genesis and growth which was discovered by ilizarov.

The first biological law is

Tension stress effect :

"slow and steady traction of tissues caused them to become metabolically activated ,resulting in an increase in the proliferative and biosynthetic function."

The tension stress effect permits the development and formation of new tissues when used in conjunction with the ilizarov ring fixator attached to the

bone fragments.the gradual traction applied ,On living tissue creates stresses on living tissue,stress that stimulate the regeneration and growth of tissues structures.the generative process highly depend upon the adequacy of the local blood supply.the main principle force responsible for tissue genesis is neovascularization.

Early bone formation occurs by the intramembranous ossification and is located parallel to the force applied.

From this second biological law arises: The shape forming process acting upon bone tissue are dependent upon The magnitude of the applied load and adequacy of blood supply.the most important condition is preservation of local blood supply,the nutrient artery in the bone marrow which is the responsible for two third of cortical blood supply, one third of blood supply comes from periosteal arterioles.so preservation of both blood supply is crucial for regeneration.

The Ilizarov ring fixator different from other external fixator is

1) Careful approach
2) Attention to preservation of the frame application
3) Manipulation of the bone fragments
4) Blood less surgery
5) Facilitate to achieve good anatomical reduction without wide skin opening

The early mobilization of the patient can be initiated and limb function can be preserved with ilizarov ring fixator beside that activation of local blood

circulation ,axial loading on the limb fixed with the frame stimulates micro motion of the tensioned ilizarov wires .it seems puzzling thin wire which withhold enormous stress provided by the axial load on limb over a course of several months of treatment and it can also bear the distraction and compression forces without breaking and cut through the bone tissues.

The unique ilizarov ring fixator system produces a much lower axial stiffness and axial loading force, which distribute the load to all parts of the frame then do the uniplanar and biplanar fixators.

The optimal biomechanical characteristics for the bone stabilization achieved by these wire and ring combination of ilizaorv method. The wire is one of the main component of the fixator system which determine the treatment and final results by bone fragment alignment along with all the other necessary position of the fragment correction.

Half pin usage is contradicts the ilizarov principles of the stiffness and elasiticity achieved through small diameter tensioned wires.

The tensioned wires are remarkably resistant and in addition they have enough elasticity so as to allow proper biological stimulus to bone healing. The restricted elasticity of the tensioned wires allows for cyclic micro motion at the fracture or osteotomy site. This was shown to activate the piezoelectric phenomena in the cells of bonemarrow, in compact bone, in the newly developed regenerate. This has been considered to be a stimulatory to bone healing, if the soft tissue are stimulated by elastic micromotion, the nerve impulse are activated, and help control the passage of electrically charged ions through the

cells activating their ion channels.because of tensioning effect of the wires,the bone is contionously loaded unlike a plate or any other type of internal fixation.this limited elasticity type has particular advantage.it generate more callus formation and maturation.dr.ilizarov considered this mechanism to be an analog to the mechanism of the fetal growth plate activity.the exact mechanism of exiting micromotion –cellular development is not completely known.

The main and obligatory rule is that wire fixation to a ring must beproperly and well tensioned that is the part of biomechanics of the Ilizarov method.

The strength of wire tensioning determine the quality of bone healing and bone regenerate development. Increased Ilizarov wire tensioning provide ,

The Suitable balance in the stability and flexibility of the construction of frame.

The Exact strength of tensioning depends up on

1) Frame construction
2) Local bone condition
3) Functional wire loading

Over the long course of treatment only stable frame construct and tensioned wire can sustain the required loading force and perform the task .

Biomechanics for the fracture treatment

Frame cannot be assembled in advance like in bone transport because the various fracture patterns and fragment displacement is so much diverse so preassembled frame constriction is not suitable for all cases.

The Ilizarov circular ring fixator system application can be considered alternative to skeletal traction and application of cast. Thecylindrical shape of the Ilizarov ring fixator system replicates the cylindrical shape of the tubular cortical bone, cylindrical shape of this fixator is very suitable for all necessary manipulation for the fixation and reduction of all bone fragments.Main difference of biomechanics in fracture treatment with the correction procedures consists of speed of fragmentsmanipulation. Few cases straightaway stabilization and frature reduction can be achieved but in some cases significant fragment displacement corrected bysubsequently tensioning the off center wires.

Advantages of Ilizarov Ring fixator for fracture management

1) Anatomical reduction can be achieved
2) Stable fixation provided by applying multi planar directed wires
3) Correcting the deformity with olive wires
4) Early mobilization and weight bearing can be allowed
5) Easy approach to wound in compound fractures
6) Secondary corrections can be possible

OBSERVATION AND ANALYSIS

Chart 1. Age and Sex Distribution

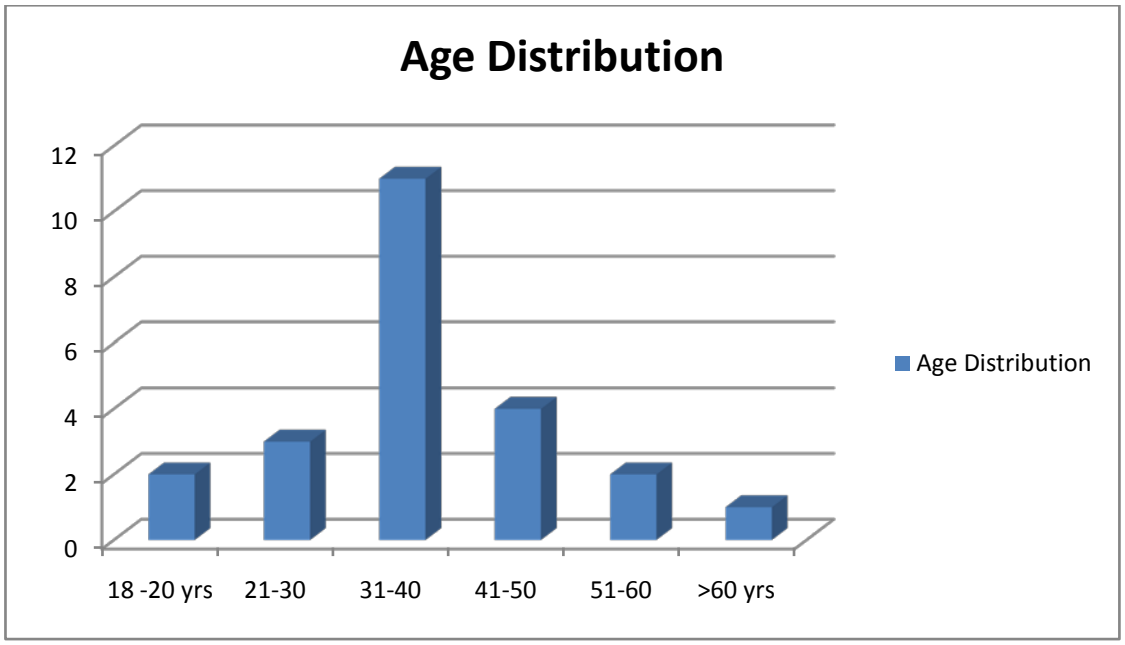
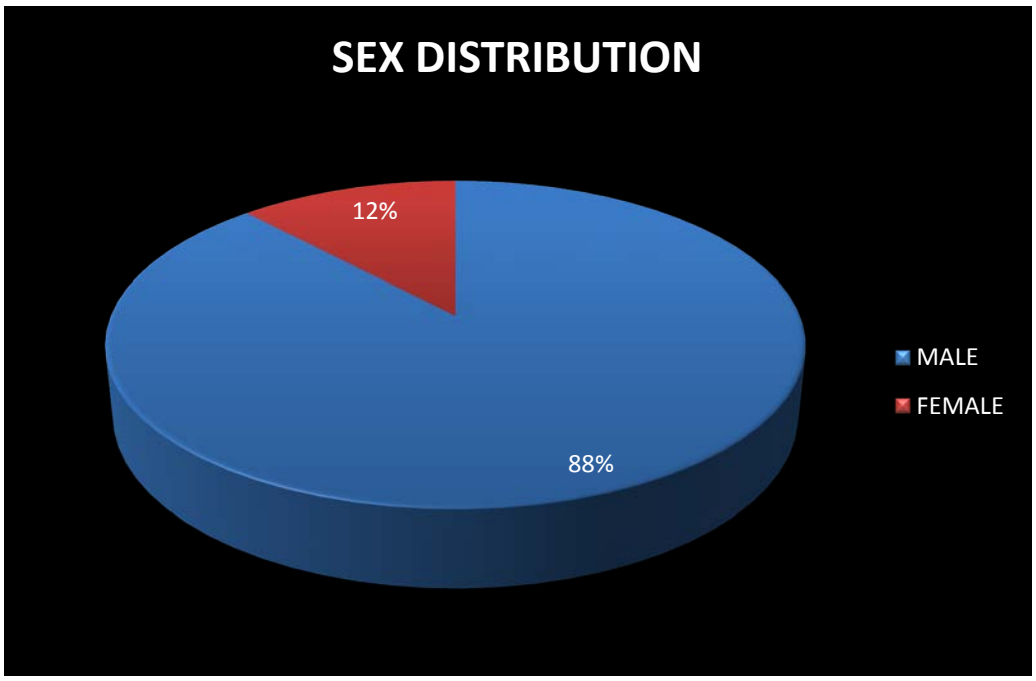


Chart 2



The study encompasses of patients in the age group between 20 and 60 years. Most of patients in the age group between 30 to 40 years, they fall in working group of population.

Most of the patient in our study is male, they are the main source of income for their families.

Table .9 Age and sex distribution

S.No	Age	Male	Female	Total	Percentage
1	18-20 YRS	2	0	2	9%
2	21-30 YRS	3	0	3	13%
3	31-40 YRS	12	1	13	48%
4	41-50 YRS	2	2	4	17%
5	51-60 YRS	2	0	2	9%
6	>60 YRS	1	0	1	4%
TOTAL				25	100 %

Chart 3 Side of injury

In our study total number of patients are 25,18 patient had open tibialfrature on right side(72%) ,7 patient had open tibial fracture on left side(28%)

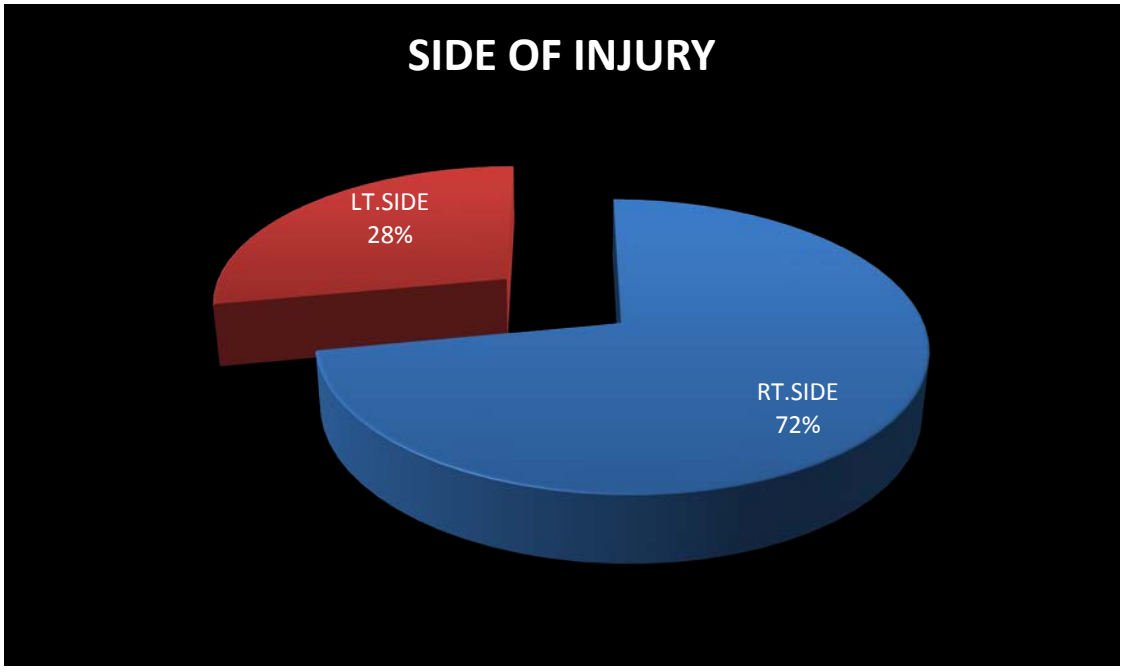
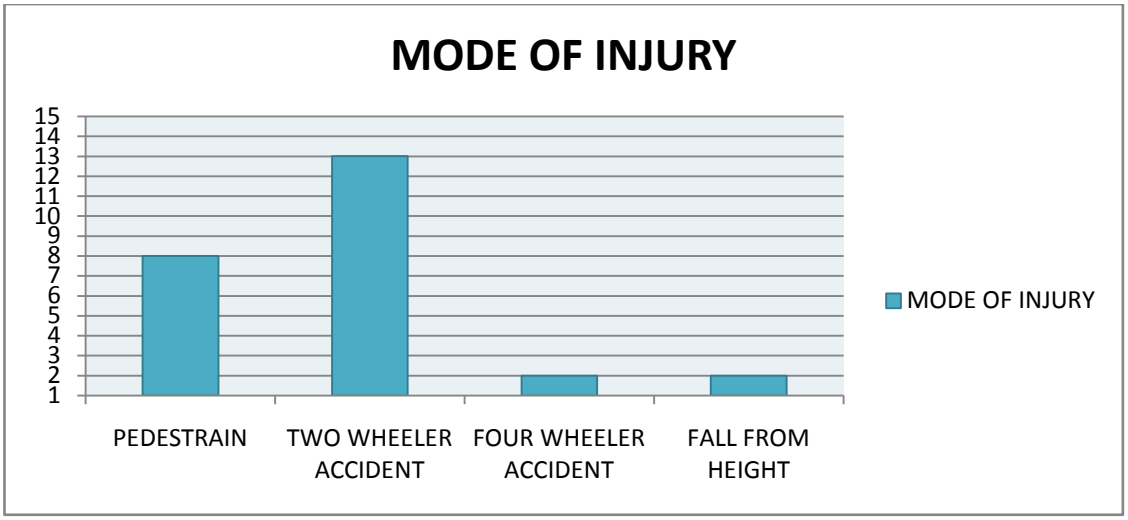


CHART.4 MODE OF INJURY

In our study we had thirteen patients who sustained open fracture of tibia due to high velocity trauma with two wheeler collision. Eight patients were fractured due to hit by a two wheeler or four wheeler in which the patient was a pedestrian. Two patients' sustained open tibial fractures due to four wheeler accidents and two patients had fracture due to fall from height.



In our study majority of the patient had open tibial fracture because of two wheeler accidents

Table 10. Distribution of types of fracture

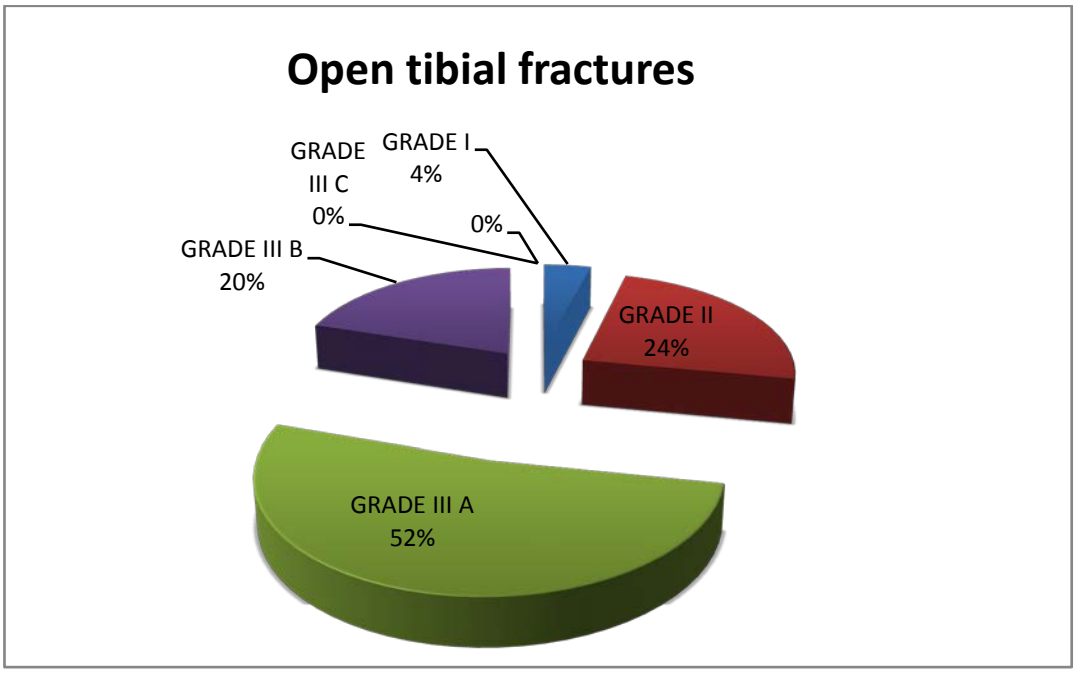
TYPES	COMPOUND
ISOLATED TIBIA	3
BOTH BONE	22
TOTAL	25

Out of 25 cases considered in the study, 22 cases had both bone fracture with compounding, 3 cases only tibia was fractured with compounding, we followed Gustilo-Anderson classification system for compounding fractures,.

These compound injuries range from grade 1 compound to grade 3B injuries. We have not encountered patient with grade 3C compound injuries in our study.

Chart 5. Distribution chart open tibial fractures

In our study we 13 cases wereGRADE IIIA compound fractures and 5 cases wereGRADE III B and 6 cases were GRADE II, only 1 case was GRADE I compound fracture.



Out of 25 open tibial fractures in 3 cases only the tibia was fractured and fibula was intact.

Chart 6. Distribution chart Isolated open tibial fractures

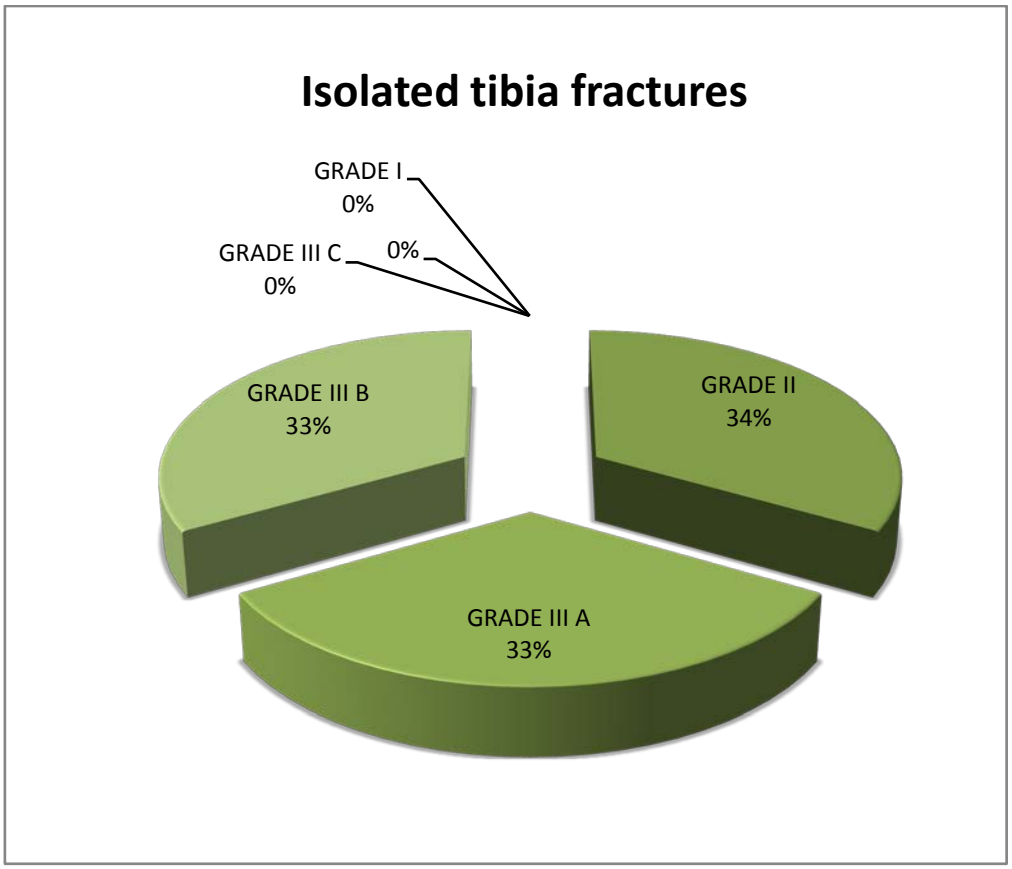
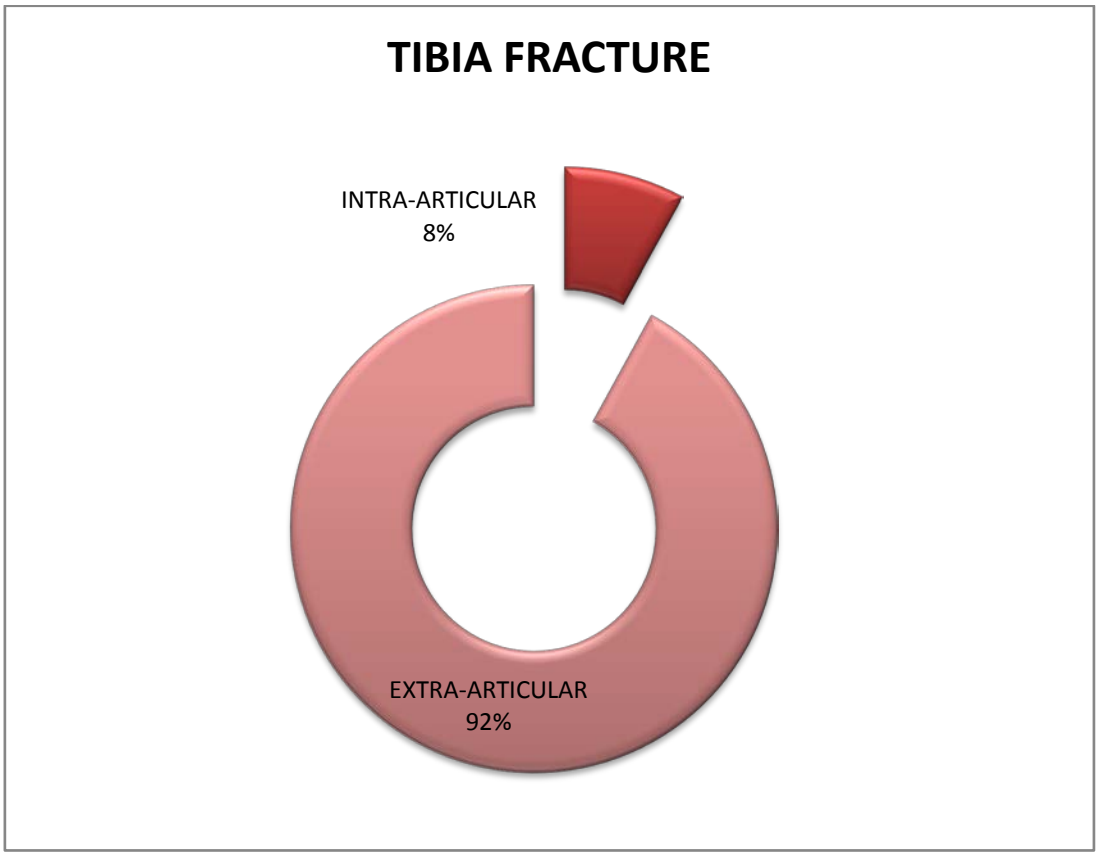
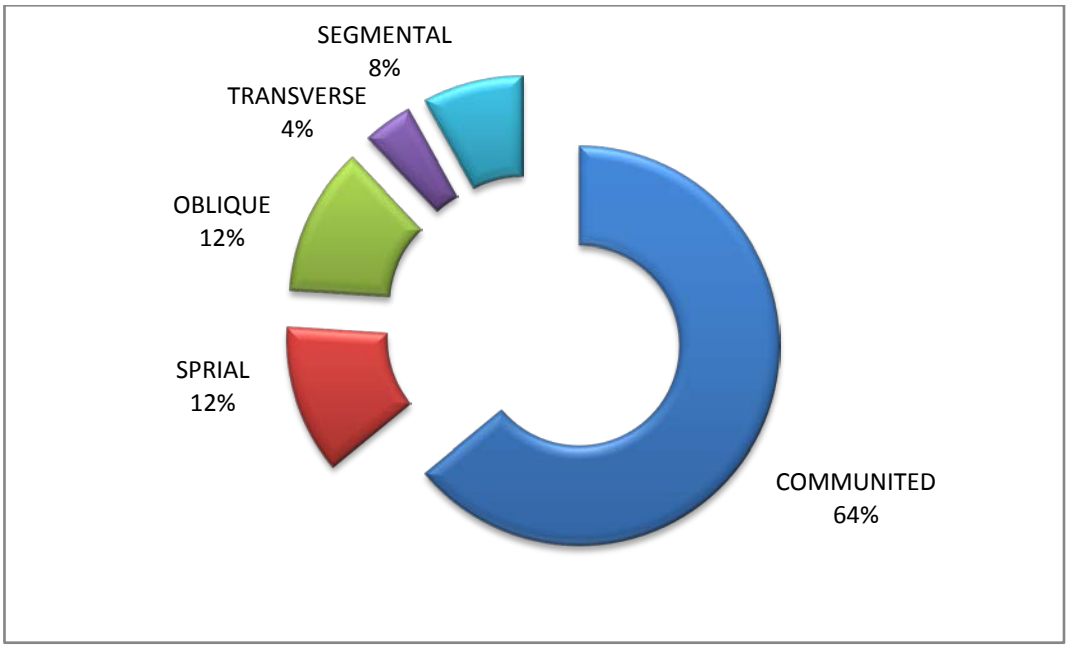


Chart 7. Tibia fractures – intra-articular and extra-articular Distribution



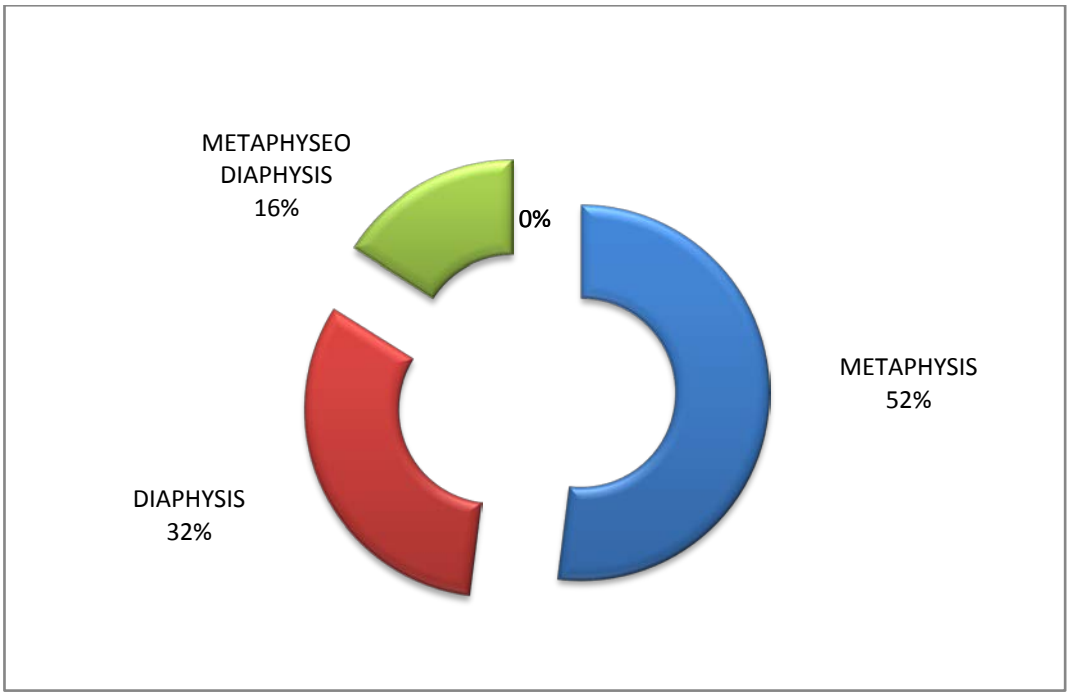
Among 25 Cases of open tibial fractures, 2 cases were intra-articular fractures accounting for 8% of open tibia fractures. 23 cases were extra-articular fractures accounting for 92% of open tibial fractures.

Chart 9. Site of open tibial fractures



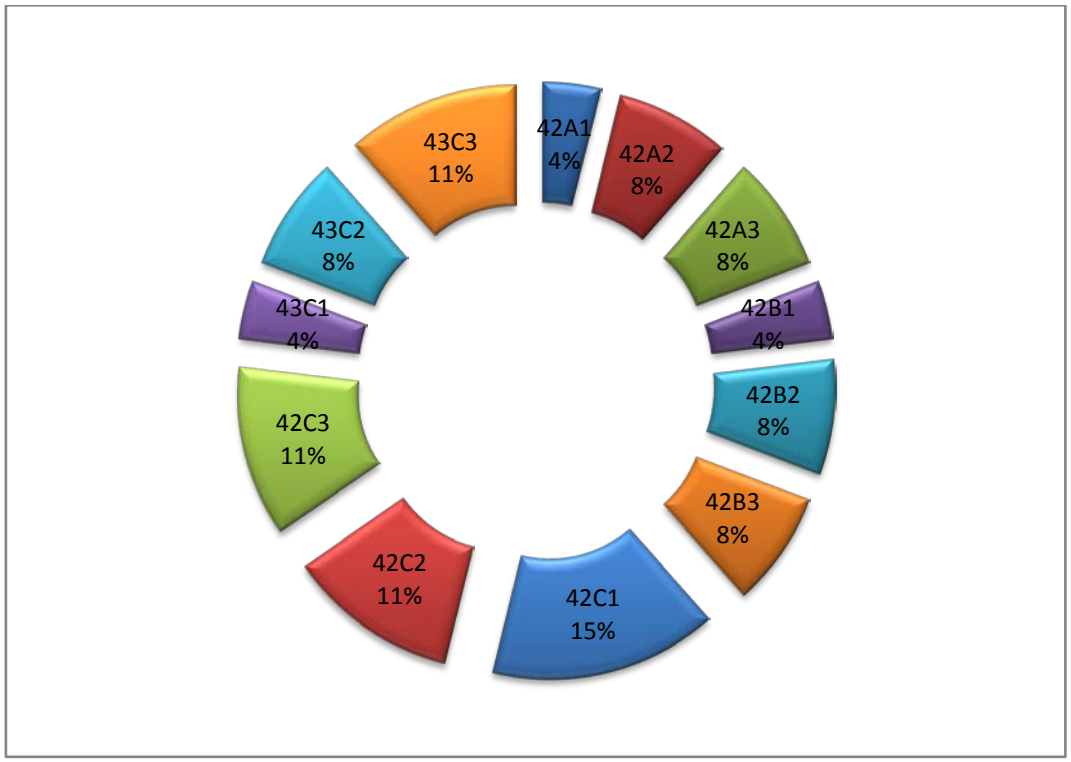
Various pattern of tibial fractures we encountered in our study, majority of cases we encountered with severe communition it account for 16 cases (64%) 2 cases were segmental pattern ,1 transverse fracture and 3 oblique and 3 spiral type of fractures we encountered in our case studies

Chart 10. Site of open Tibial Fracture



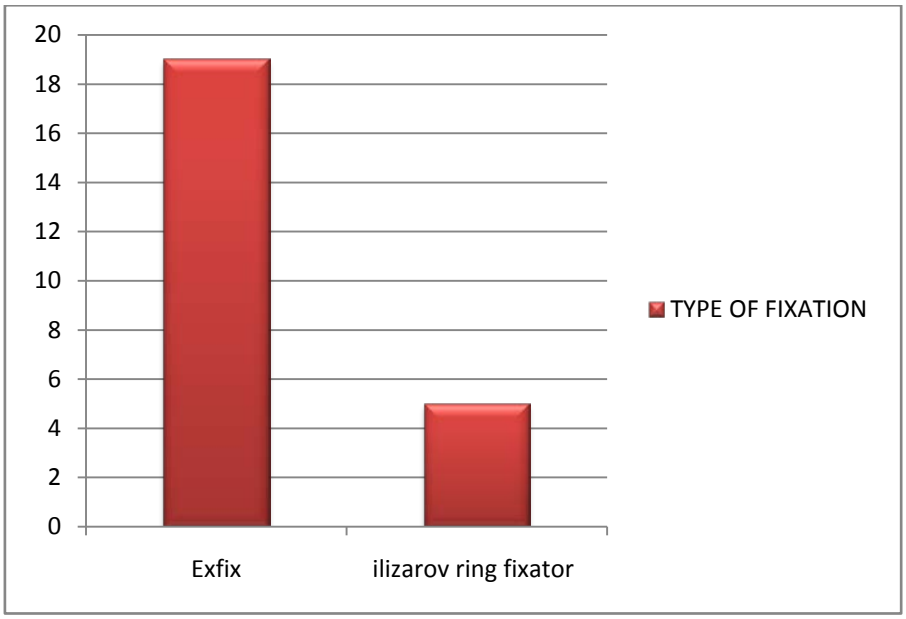
Among 25 cases of open tibial fractures , 8 cases were confined to diaphyseal region (22%), 13 cases were confined to metaphyseal region and 4 were metaphyseodiaphyseal fractures (78%)

Chart 11. AO Classification



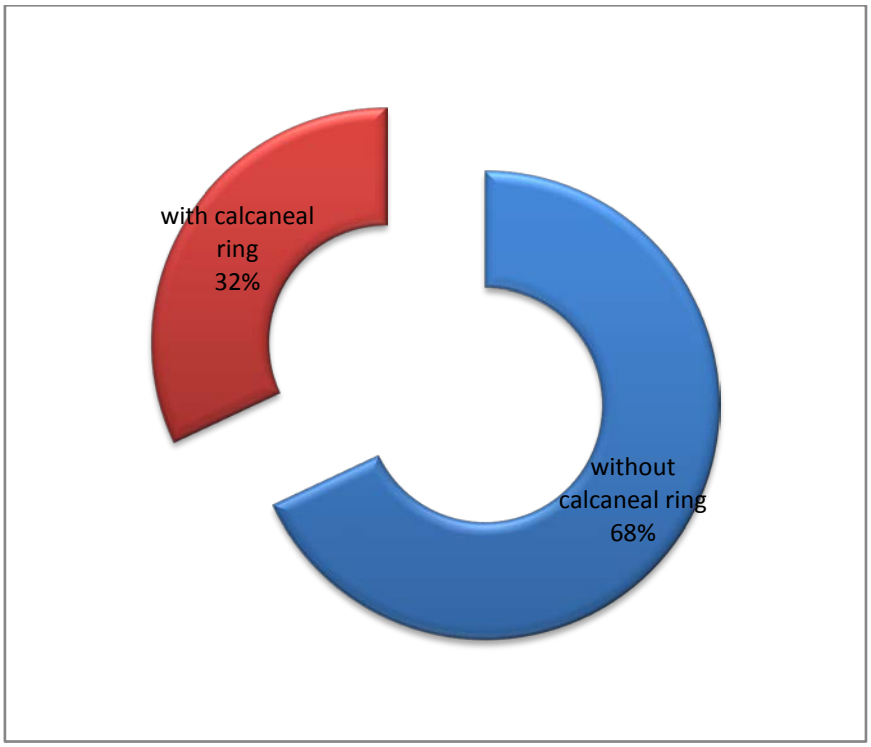
Among 25 cases in our study various type of open tibial fractures are present in that most of the cases are fall on 42C1 type of fractures in AO classification

Chart 12. Type of Fixation



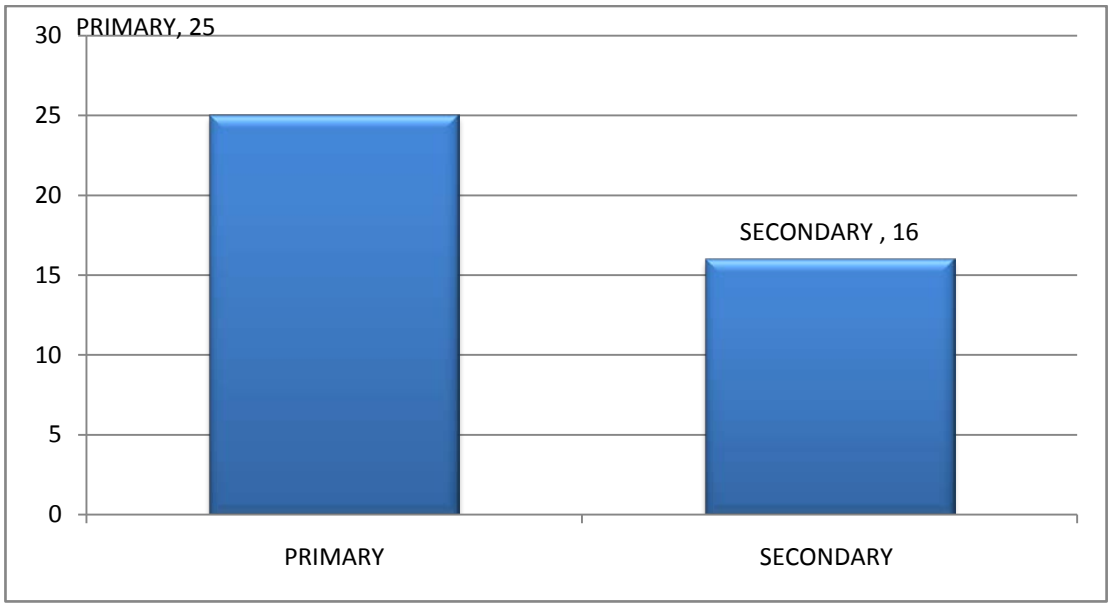
Among 25 Open tibial fracture cases, 19 cases were managed initially with external fixators,6cases were directly managed with ilizarov ring fixator , In the external fixation category 2 cases we applied knee spanning exfix and other cases are managed with tibial exfix .extenal fixator is only for tempory fixation all the cases has been converted to ilizarov ring fixator only patient assessed..

Chart 13. Ilizarov Ring Fixtaor



In our study most of the distal tibial fractures with articular involvement calcaneal ring was applies, few distal fracture where more than one ring can't be applied we added calcaneal ring for stable constrct.in our study among 25 cases we applied for 8 cases.

Chart 14. Wound Debridement



In our study we have done through wound debridement in all cases on the day of admission in emergency operation theater. Most the cases we applied external fixator system, few cases we have done only wound debridement and primary closure those cases are directly managed with definitive fixation by ilizarov ring fixator

Among 25 open tibialfractures,16 cases under went secondary wound debridement on the day of application of ilizarov ring fixator .

Table 11. Day of Definitive Fixation

S.No	Timing of fixation	Number of cases
1	Within 2 days of injury	**5**
2	3 day after injury	**12**
3	4 day after injury	**3**
4	5 day after injury	**5**
	Total	**25**

Once the patient has been initially stabilized ,classified and assessed ,the definitive fixation was done depending upon the fracture type. All the open tibial fractures in our studies are fixed with ilizarov ring fixator with 5 days of injury

Table 12. Associated Injuries

S.No	Fracture	Number of cases	Management
1 1	Contralateral Lower Limb: Contralateral femur fracture	1	Closed IMIL nailing
	Contralateral tibia fracture	1	Closed IMIL nailing
2 2	Contralateral upper limb: Distal radius fracture	2	Ligamentotaxis using wrist spanning exfix
	Ipsilateral upper limb:		

3	# Both Bone Forearm	1	ORIF with PO
	Distal humerus fracture	1	ORIF with PO
	Metacarpal fracture 2^{nd},3^{rd}	1	K wire fixation
	Clavicle fracture	2	Conservative – 1 ORIF with PO -1
4	Ipsilateral lower limb: Calcaneal fracture	2	Conservative - 1
	Bimalleolar fracture ankle	1	ORIF with PO for fibula CRIF with malleolar Screw fixation for Medial malleolus
	TOTAL	12 12	

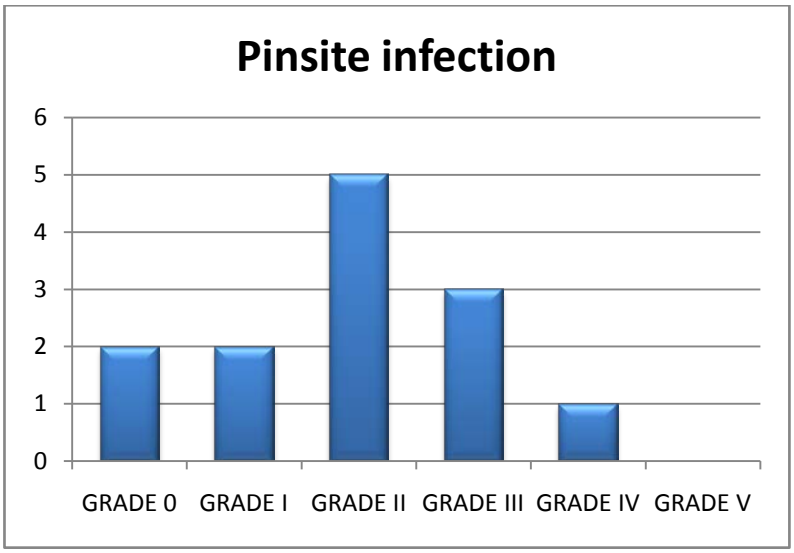
In our study we had 15 cases associated with other bone fractures ,associated fractures are fixed once open tibial fracture is fixed with ilizarov ring fixator

Table Post Operative Complications

S .No	Complications	Number of cases
1	PinsiteInfection	10
2	Delayed union	4
3	Non – union	Nil
4	Malunion	1
5	Shortening	2
6	Ankle stiffness	1
7	Knee stiffness	3
8	Equinus	1
9	Deep venous thrombosis	Nil
	Total	22

Among 25 cases in our study 10 cases had pin site infection,4 cases with delayed union and 1 case with non-union , in 1 case with Malunion occurred. We have not encountered fat embolism and DVT in our study.

Chart 15. Pinsite Infection –Dahl Et Al



Grade 0 has been managed with weekly pin care was advised

Grade I has been managed with frequent pin care ,it consist daily cleansing with mild soap ,half strength hydrogen peroxide and normal saline,

Grade II,III has been managed with antibiotics and daily pin site care

Grade IV has been managed by offending pin was removed immediately ,local soft tissue was debrided with peroxide and astringent irrigation was done, until the radiolucency appear on the plain radiograph pin site care was continued.

We haven’t encountered Grade V pin site infection in our study.

Table no.14. Delayed Union

S .No	Segment of the bone	Management
1	Metaphysis	Bone marrow injection
2	Diaphysis	Bone grafting
3	Diaphysis	Bone grafting
4	Diaphysis	Enbloc resection and bone transport
5	Diaphysis	Bone marrow injection

Out of 25 cases of open tibial fractures we encountered delay unionin 5 cases.2 cases were managed with bone marrow injection on 3 rd month,2 cases were managed with bone graft on 3rd month. In one case we have removed the devitalized bone fragments and sclerotic fragments.corticotomy and bone transport done, length was achieved. Delay union most often occurred in the diaphysissegment .

Non union

We didn't encounted any nonunion in our study.

Malunion

Malunion occurred in one metaphyseal fractures of tibia treated with plating and one metaphyseal fracture of femur treated with plating. No specific intervention was done in these patients.

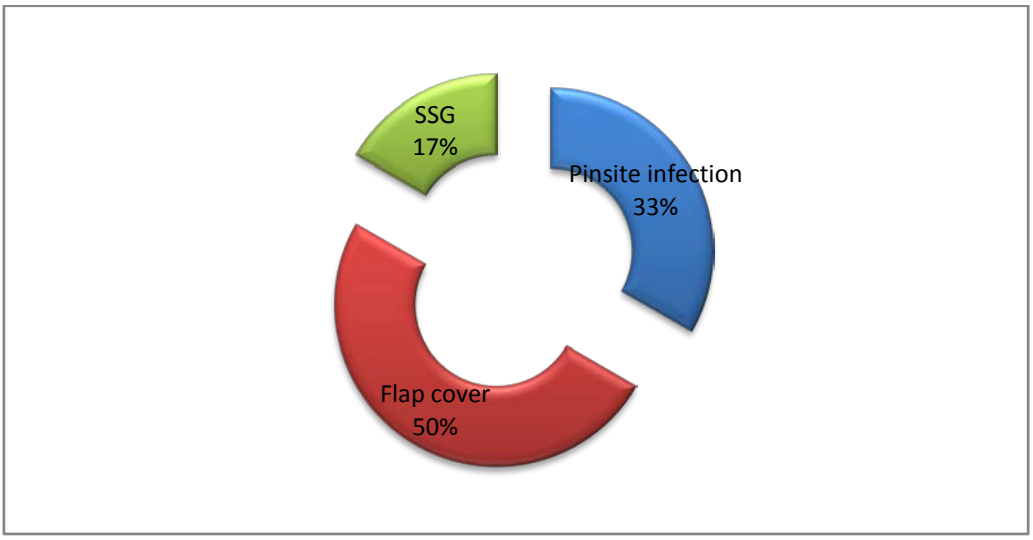
Table No.15. Shortening

S .No	Shortening	No.of cases	Management
1	<1cm	1	Shoe rise
2	1-2.5 cm	1	Shoe raise
3	>2.5cm	Nil	Nil

In our study out of 25 open tibial fractures two cases with shortening of limb, one case had 1cm shortening and other case was with 1.5cm shortening those cases are managed with shoe rise.

Chart 16. Pin Realignment

Pin realignment has been done for few cases for graft flap cover, pin site infection,



For various reason we has been removed the pin and reapplied in different sites.Most of the time we have exchanged the position of the pin for flap cover application (33%)

Table 16. Bony union period

S.No.	Time period	No.of cases	Percentage
1	< 4 weeks	0	0%
2	4 weeks – 6 weeks	1	4%
3	6 weeks – 3	7	28%
4	3 months – 6	12	48%
5	6 months – 1 year	5	20%
	Total	25	100%

In open tibial fracture cases, the average time taken for union ranged from 12 – 16 weeks. Union was delayed in few cases with infection and in cases

severe communition and fragment loss. Which all managed with additional procedures; all the cases had union in our study without infection. We found that clinical union was 4- 6 weeks earlier than then radiological evidence. Prolong Wound exposure and stripped periosteum and grade 3b cases we found that union was delayed compare to grade 2 and grade3a patients.

KNEE - RANGE OF MOTION

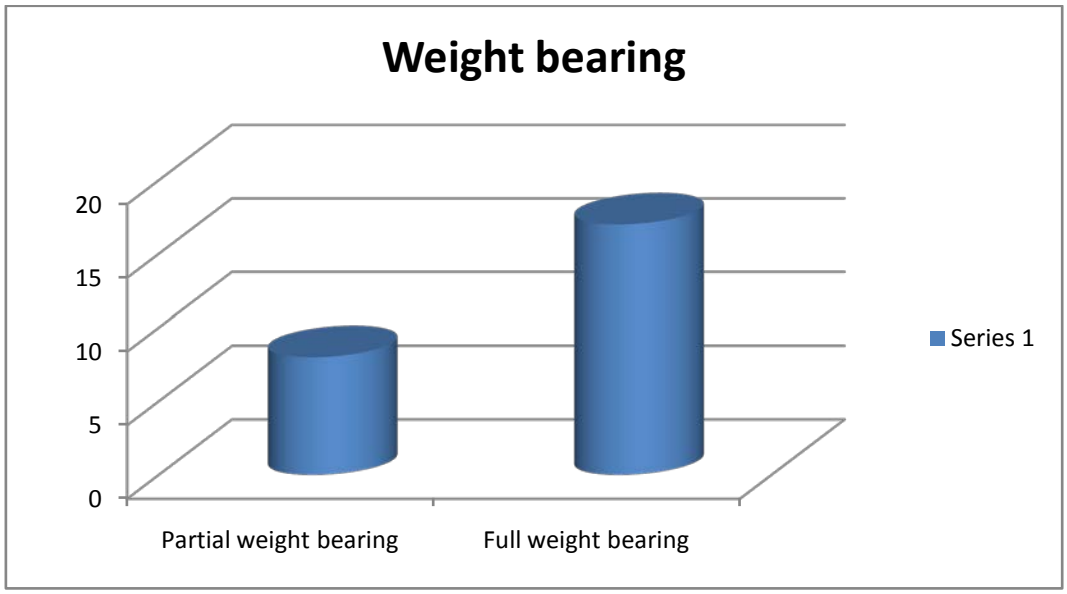
The knee and ankle range of motion was an one of the important criteria in the functional assessment after bony union. The maximum range of knee motion recorded in our study ranged from 0 degree to 90 degrees. Beyond 90 degree patient couldn't able to move because of proximal most ring which restrict the further movements. The minimum range of knee motion recorded in our study ranged from 0 – 30 degrees. The average range of motion at knee joint in our of study of 25 patients ranged from 50 - 90 degrees ,out of 25 cases three cases we had knee stiffness at 30 degree which was corrected by aggressive physiotherapy while on ring fixator itself.

ANKLE- RANGE OF MOTION

The ankle range of motion was initiated on the next day. The maximum range of ankle motion recorded in our study ranged from 0 to 35 degree of dorsiflexion and 0 to 25 degree of plantar flexion, the minimum range of ankle motion recorded in our study ranged from 0 to 10 degree of dorsiflexion and o to 10 degree of plantar flexion, except one patient all the patient regained full range of motion after ring removal with aggressive physiotheraphy.one patient had

equines deformity which was corrected by foot assembly, hinges and distraction rod which are connected in the same ring fixator

Chart 17. Weight bearing-Chart



In our study we advised partial weight bearing with walker until wound get settle. Once wound was healed, advised for full weight bearing periodically we measured the weight which beared on fractured leg with ilizarov ring fixator .

In our study 18 patients can able to bear full weight after 2 months without any pain and discomfort, they can able to walk without any support. They are very much comfortable too. Union rate in those patients were achieved earlier than the partial weight bearers. We conclude that full weight bearing can be possible and it will enhance the fracture healing prevent the knee stiffness. We did nt encounter any wire breakage and bending of construct.

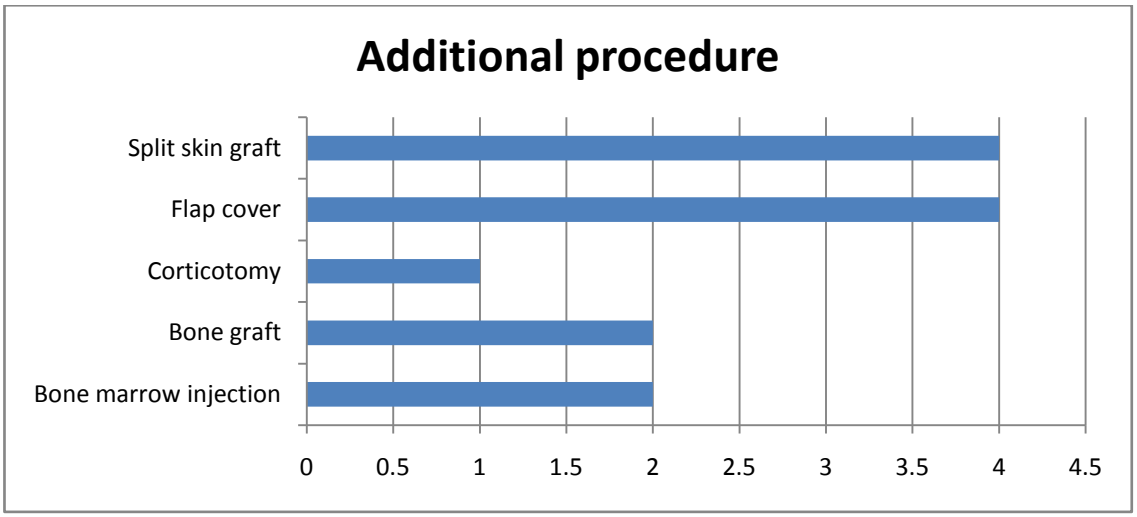
Figure 6,7

SOFT TISSUE COVER:

Figure-8, 9, 10

Whom ever needed soft tissue cover which has been given in proper way by using ilizarov ring fixator itself,it has been shown in those pics.

Chart 18 Additional Procedure



Fixator removal

In our study union was achieved in all cases ,the eariliest evidence of radiological union at the fracture site was observed after 2 months of surgery.

In our study we considered union when both clinical and radiological criteria was established,Clinical criteria

1) absence of pain at rest

2) absence of pain on movement with the patient bearing full weight on the limb, the fixator attached but dynamised**.**

Radiological criteria

1) Presence of bridging callus in alteast three planes

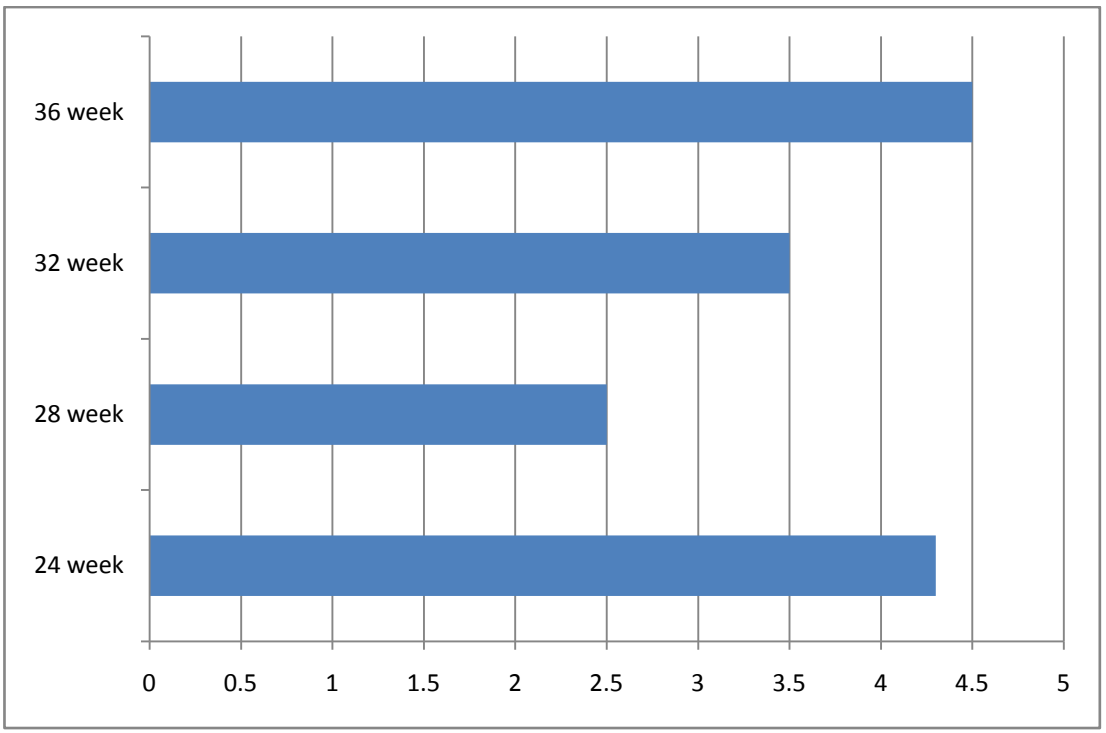
When both criteria is fulfilled we remove the external. The period of dynamization in our study was 1 month

Earliest ring removal at 6th month and for 3 cases we removed the ring fixator after 8 months because of segment fracture and one case was delay in

union, one case we did bone transport so we waited for to consolidate the regenerate.

Figure-11 **Figure-12**

Chart-19 Fixator Removal



RESULTS AND

DISCUSSION

DISCUSSION

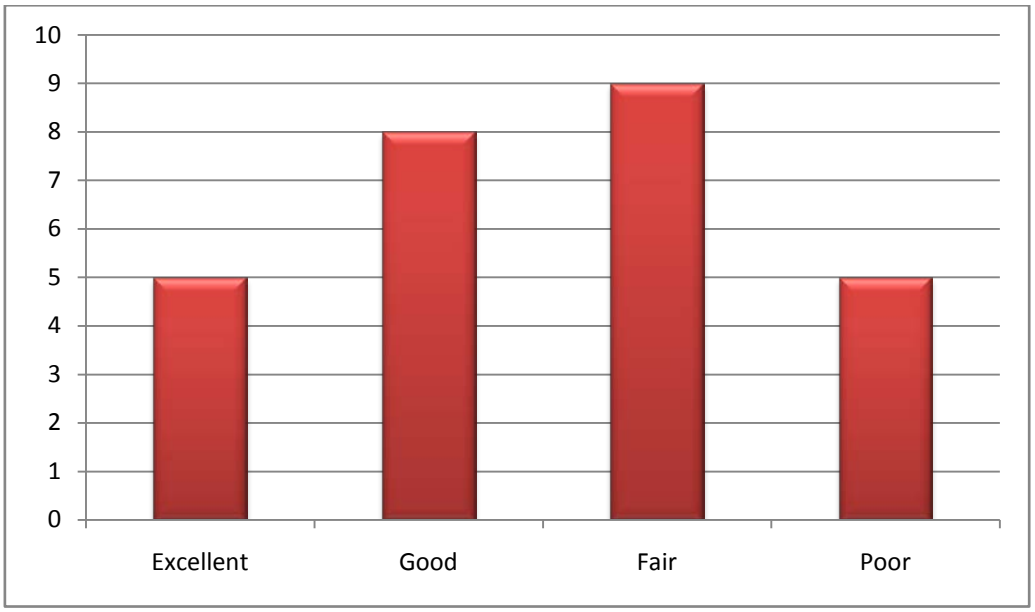
In our study comprises of 25 cases of open tibial fractures and all the patients were managed with wound debridement and ilizarov ringfixator as definitive fixation according to the protocol as mentioned in the methodology. The functional outcome of all the patient assessed after bony union using tucker's criteria.

FUNCTIONAL OUTCOME MEASUREMENT

Table No .17. Tucker's Criteria

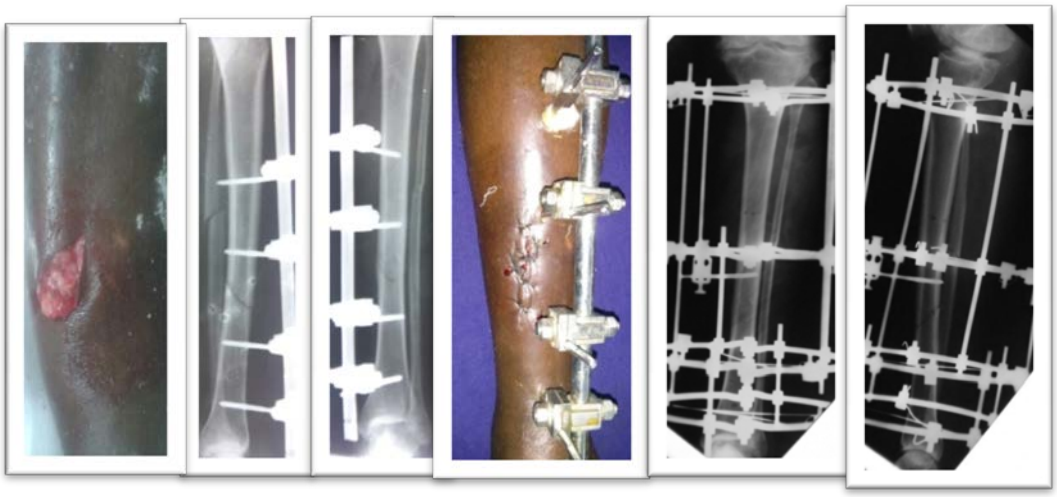
S.No	Outcome	No.of cases	Percentage
1	Excellent	5	20.52%
2	Good	9	33.33%
3	Fair	8	29.63%
4	Poor	3	16.52%
Total		25	100%

Chart 21. Tucker's Criteria



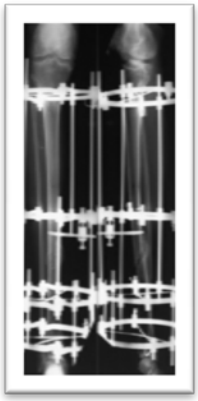
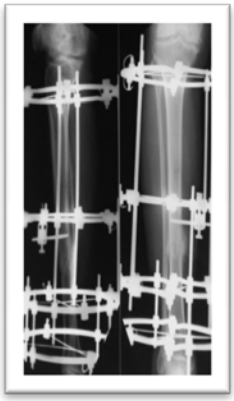
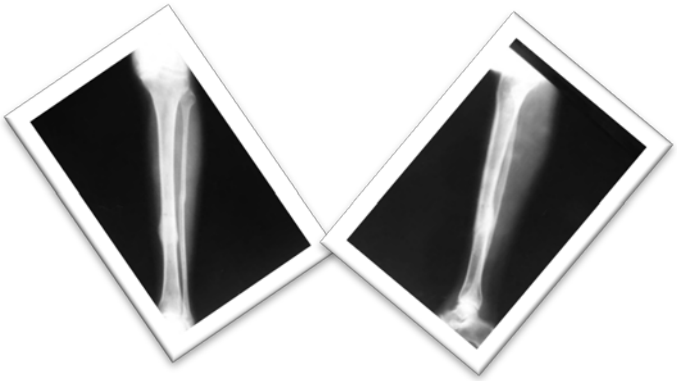
According to tuckers criteria maximum number of the patient we had excellent to good functional outcome,

CASE 1



Pre-Op On External Fixator Immediate Post Op

After 6 Weeks

3 Months 5 Months 6 Months

CLINICAL OUTCOME

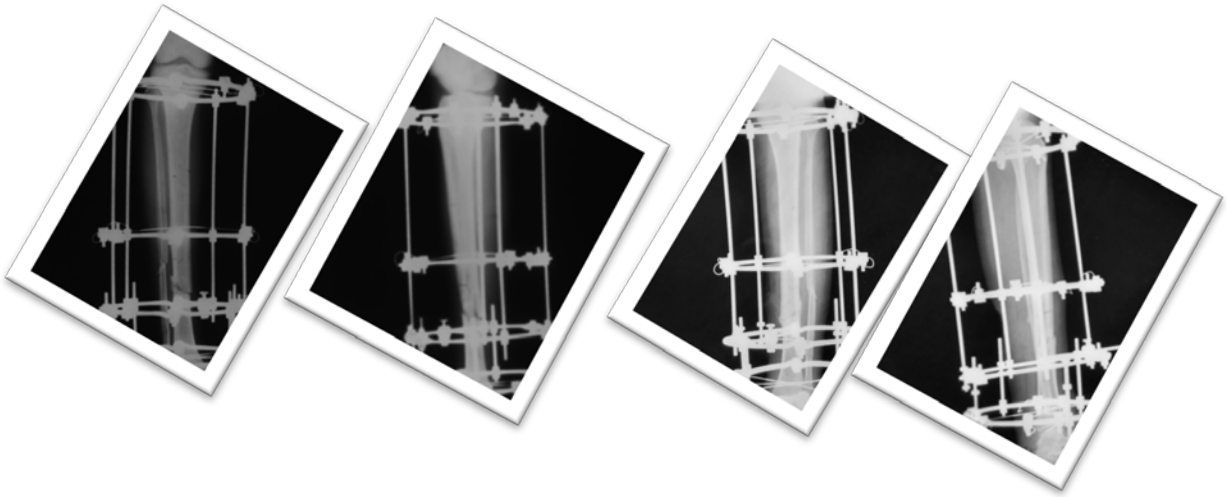




CASE-2

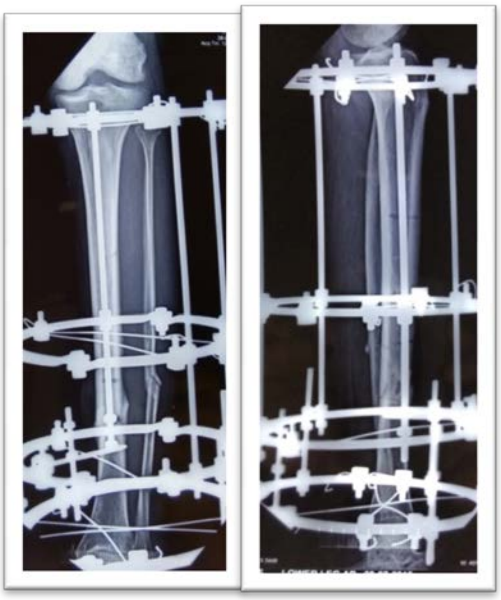
Pre-Op

On External Fixator



Immediate Post Op

6 Weeks



3 Months

5 Months

CLINICAL OUTCOME

RESULTS

EXCELLENT OUTCOME CATEGORY

There were five patients in our study had excellent outcome,three patients had grade 2 injury and had wound debridement and definitive fixation with ilizarov ring fixator with 2 days.two patient had grade 3a open injury and fixed with ilizarov ring fixator on day 4. All these patients were started on early mobilization and partial to full weight bearing. None of these patients had infection. All these patients had no pain or any deformity.no obivious pinsite infection, average period of ring fixator was 4 – 6 months, all these patients returned back to their pre-trauma works with ring fixator itself . The knee range of motion was from 0-90 degrees in two patients, 0 – 80 degrees in two patients and 0 – 70 degrees in one patient on fixtor ,after removal all patients gained full range of motion

GOOD OUTCOME CATEGORY

There were nine patient with good functional outcome in that two patients were grade two open fractures and fixed with ilizarov ring fixator as definitive procedure on third day and five patients were grade 3 a open injury fixed on day 3 .and two patients were grade 3b compound injury which we fixed on day five,all gained near full range of movement after removal of fixator,whom need plastic cover which has given by the plastic surgeon as early as possible.

FAIR OUTCOME CATEGORY

There were eight patient had fair functional outcome ,one patient was grade 2 injury which we fixed on fifth day becaz of assessment delay and he is

old age fall on more than 60 ,external fixator was converted to ilizarov ring fixator.four patient had grade 3 a injury and fixed on day three.three cases were grade 3 b injury which got operated on day three.all patients had good union and range motion were near normal range,delayed union in few cases..which were united after bone grafting **.**

POOR OUTCOME CATEGORY

There were three patients had poor functional outcome according to tuckers criteria,one was grade 3 a it was fixed with ilizarov on day four.two patients were got fixed on day five..

COMPARISON TABLE WITH OTHER STUDIES:TABLE -19

Study	Total no case	Excellent	Good	Fair	Poor
Naveedwani et al 2010	60	48	10	2	0
Pirabdullatifqureshi	30	15	10	3	2
Janakrathod	10	8	2	0	0
SM Esmaelinejad et al	60	49	9	2	11
Mahmoud A El-Rosasy	96	50	36	6	4

CONCLUSION

CONCLUSION

Open tibial fractures are more complex injuries,in our study most of th patients fall in working group of population from 25 to 40 yrs and majority of the patients were males.In our study most of the injuries are belonged to type 111 a gustilo Anderson classification which is open tibial fractures size more than 10 cm or irrespective of wound with segmental or severe communition.so type 3a open tibial fractures are more common in these age group.associated injuries were more common among these group.it may range from ipsilateral limb injuries to other system injuries requiring intensive primary survey in these patients.

The functional outcome of open tibial fractures are highly depends in many factors The type of fracture

1) Degree of comminution
2) Shaft /intra-articular fractures
3) Type of initial procedure,
4) Timing of fixation of both the fractures,
5) Timing of initiating knee and ankle mobilization,
6) Associated complications,
7) Other associated injuries and their management .

The ilizarov ring fixator is a versatile instrument in the armentarium of an orthopaedic surgeon.in developing countries like india where all facilities for ILIM Nailing and plastic surgery are not always present it holds great promise in the management of open tibial fractures.in our protocol of wound debridement

and initial temporary stabilization with ao external fixator, followed by ilizarov ring fixator with in five days.ilizarov ring fixator is an effective form of management associated with good bony and functional outcome at the same time reducing the load in emergency management.ilizarov ring fixator allow early weight bearing ,good functional outocome,attainment of adequate limb length ,it allow wound coverage ,correct the deformity.complications associated with the ilizarov ring fixators are minor and usually do not require any intervention which can be managed with this ilizarov ring fixator itself.we highly recommend ilizarov ring fixator as an definitive fixaton in all type of open tibial fracture.

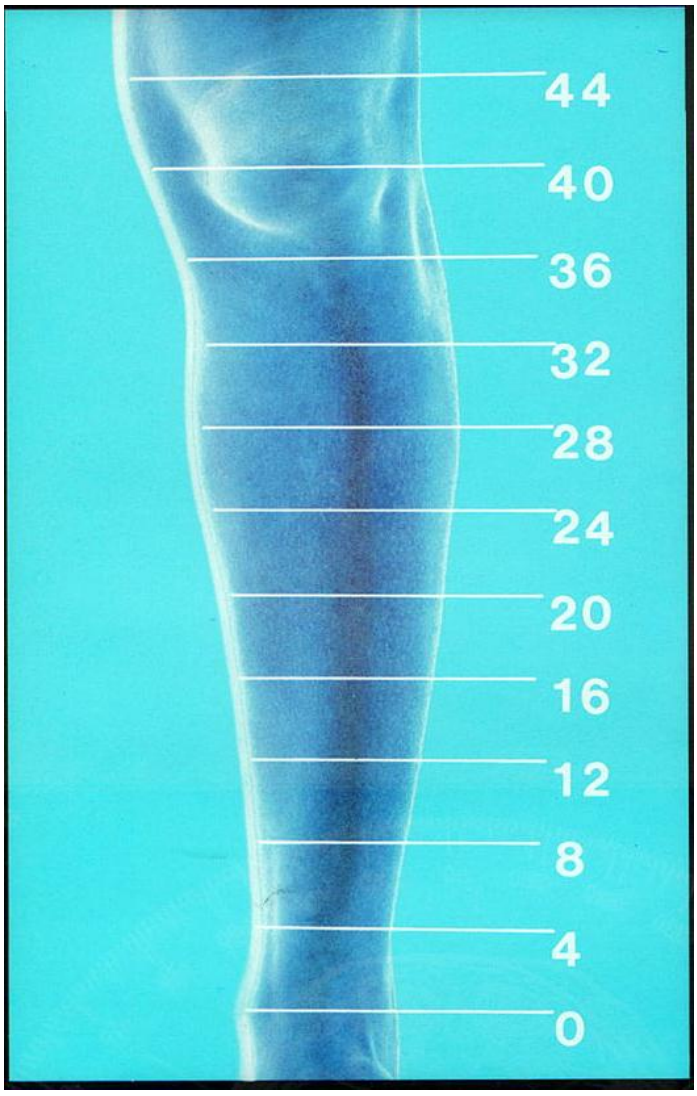
0To achieve the good functional outcome certain principle should be followed which given below

1) Adequate wound debridement with normal saline
2) Proper external fixation with AO
3) Proper antibiotics before and after surgery
4) Proper alignment of fracture fragments
5) Proper wire insertion which we have given in detail
6) Post op care
7) Daily Pin site dressing
8) Knee and Ankle mobilization exercise
9) Allow for full weight bearing
10) Adequate nutrition

This ten points for to achieve the good functional outcome in open tibial fractures

Method of insertion of trans osseous wires

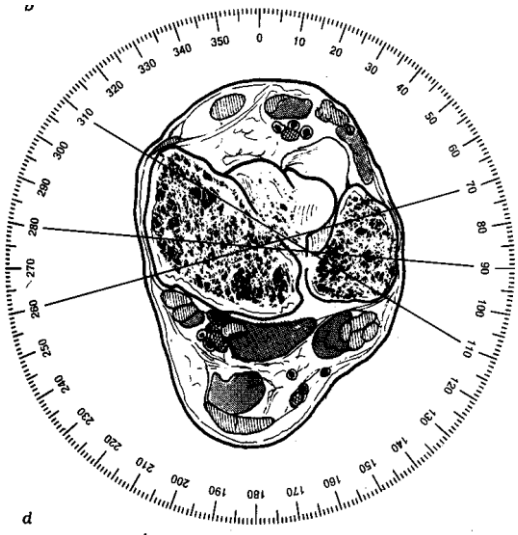
The topographic anatomy of the leg is very important while use of trans osseous wire for Ilizarov method, awareness ultimately avoid the injury of nerves and artery

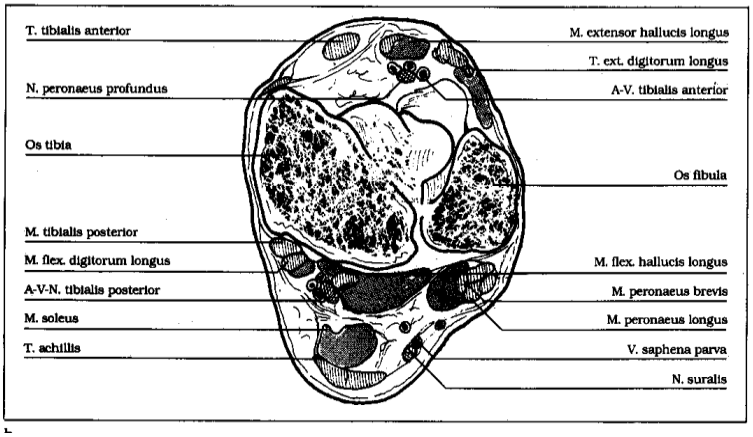


Levels of the anatomical cuts of the lower extremity expressed in centimeters

Cut 0

First transverse cut made just above the ankle joint.it correspond proximal to tip of the lateral malleolus, in this level both malleolus can be palpated





The anterior tibia A.V and the Deep peroneal nerve lie between EHL and EDL at approximately the 10 “o” clock position. The posterior tibial A.N is located in the posteromedial quadrant from 230 to 240 between FDL And FHL, Sural nerve is seen between the peroneal muscles and the Achilles tendon in the postero lateral quadrant. The most of the structures are present anterior and posterior to tibia so many locations are available for applying the wires.

First wire - transverse wire will be applied from 90 to 280 direction.it will be parallel to the knee joint line.

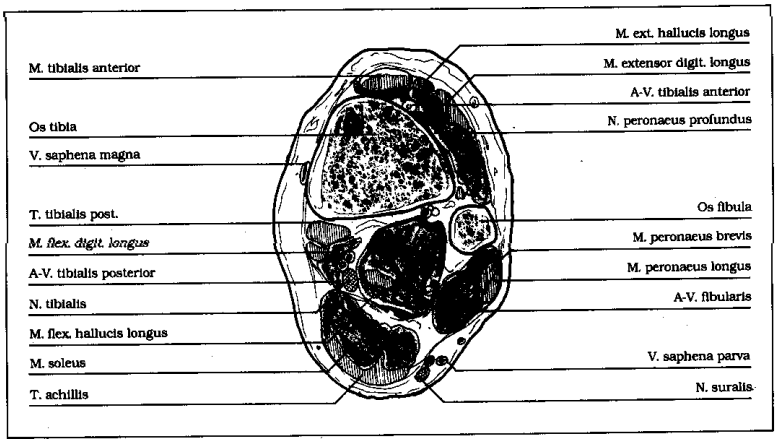
Second wire - Trans fibular wire will be applied from 110 to 310 direction, when immobilizing the tibio fibular articulation the foot should be positioned on dorsiflexion this will allow complete range of ankle motion.

Third wire –Medial phasing wire will be applied from 260 to 70 direction. All wire directions are shown in the picture.

Cut 2

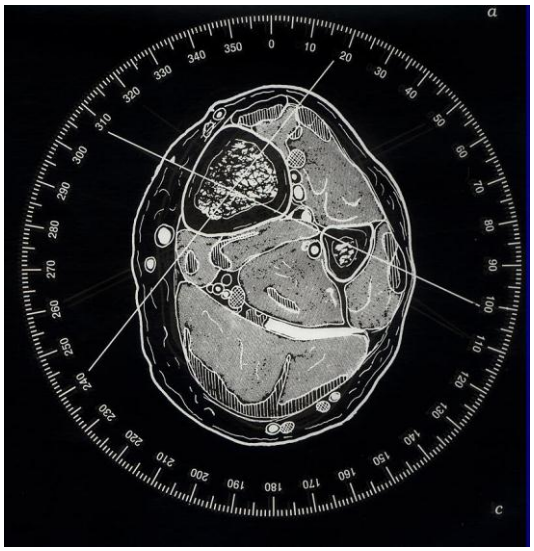
This section is" 2 t" proximal to ankle joint

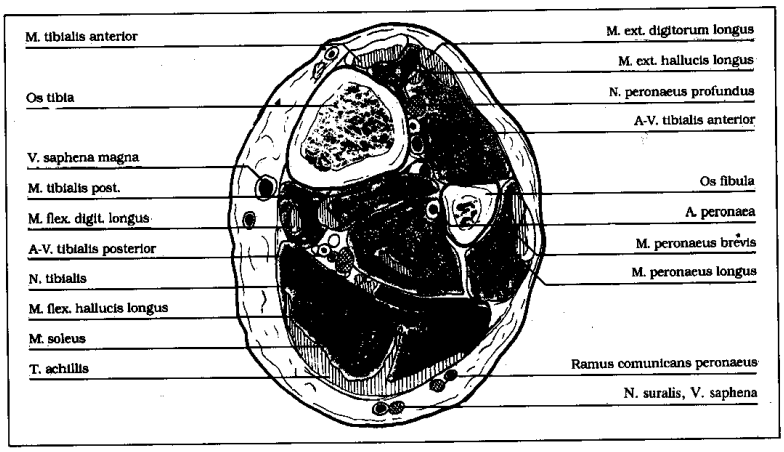
Ant. tibial artery and deep peroneal nerve are at 10 between the anterior tibial tendon and EHL ,the posterior tibial artery and nerve are at 230 Among the FDL, FHL and soleus.



The lesser saphenous .v and sural nerve runs just lateral to the Achilles tendon, at this level 70 angle of wire divergence can be achieved. Two wires can be applied at this level one is medial phasing wire (260 to 50) and transverse wire (100 to 310).

Cut 8





This section cut is performed “4t” from the ankle joint

The deep peroneal nerve is situated just anterior to the anterior tibial A.V. these structures are between 30 to 40 and covered by the EHL Muscle.

The posterior tibia A.V. and tibial N. have migrated laterally to assume a more central position under the soleus muscle. The peroneal artery is of significant size at this level and runs along the medial border of the fibula where it remains for its entire course within the leg. In subcutaneous plan the sural nerve, lesser and greater saphenous vein and communicating branch of peroneal nerve are present,

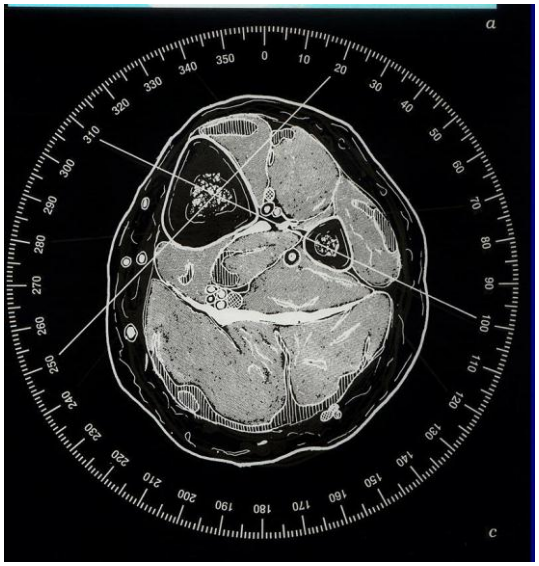
Two wires can be passed freely without damaging the vessels one is transverse wire (110 to 310) and another wire is medial phasing(20 to 240)

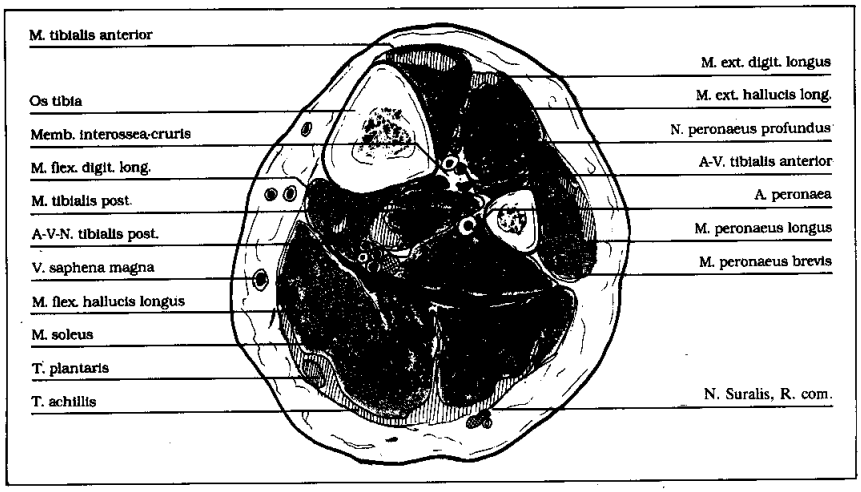
Cut 12

This section os “6t” from the ankle joint.

The anterior tibial A.V and Deep peroneal nerve have assumed a more posterior position, now lying adjacent to the interosseous membrane these are covered by the ant. tibial muscle and FHL muscle.

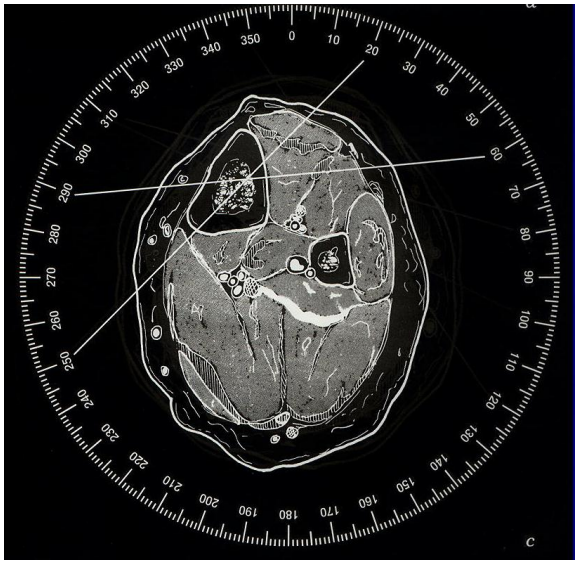
The posterior tibial A.V. and tibial N are situated centrally between the soleus Muscle and the deep posterior compartment.in this section two wires can be applied the transfibular wire (100 to 310)and medial phasing wire(50 to 280).

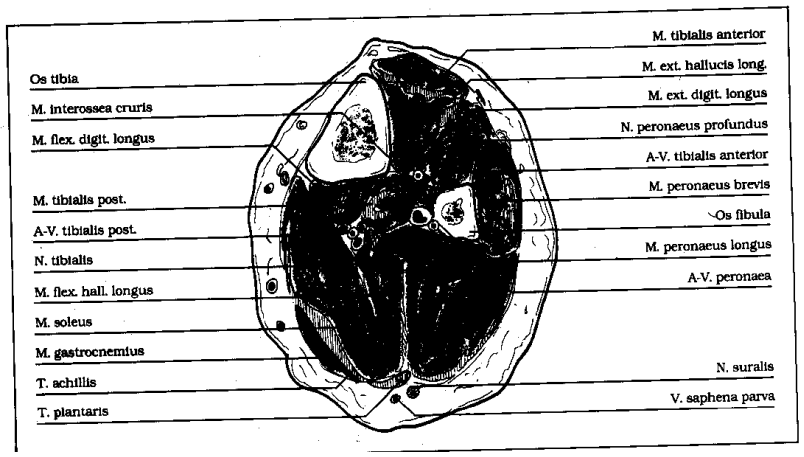




Cut 16

This level is “8t” proximal to the ankle joint ,it is just inferior to the midpoint between knee and ankle.





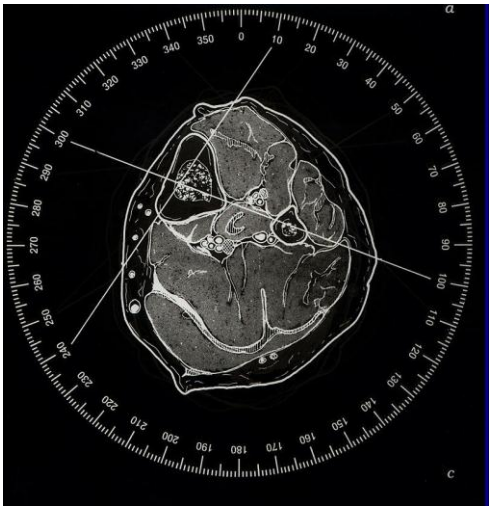
The posterior bundle is at the point of convergence of the soleus muscle. The posterior tibial muscle and the flexor digitorum longus muscle. The peroneal Artery continues just medial to the fibula and the saphenous nerve and vein are in a position similar to the previous cut.

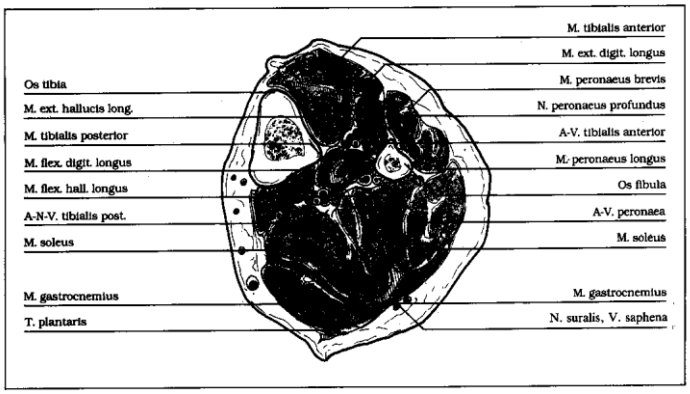
Transverse wire (290 to 60)

Medial phasing wire (250 to 20)

If fibula fixation is required this can be performed (110 to 310)

Cut 20





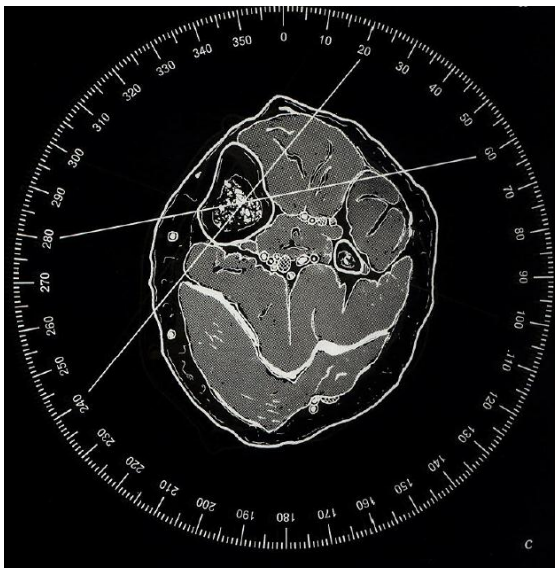
This section is located "8" distal to the knee joint, this cut is just proximal to the tibial midsection

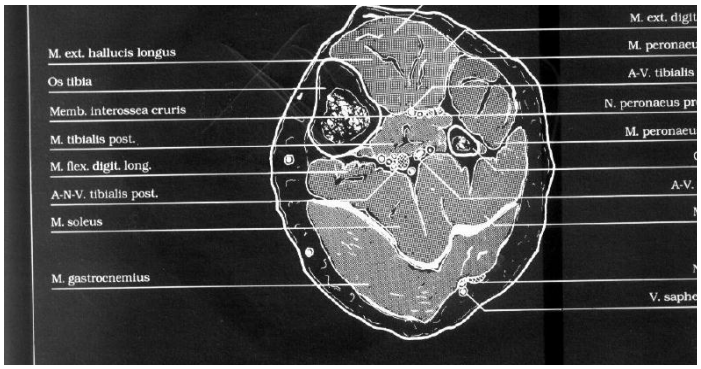
The anterior tibial A.V and deep peroneal nerve continue their course along the interosseous membrane.

The posterior tibial A.V and tibial N run posterior and lateral to the tibia at the confluence of the soleus, posterior tibial M and flexor digitorum longus muscle. The wire placement is same as before section

Cut 24

This section is taken “6t” distal to the knee joint,the major neurovascular bundle lie in the space between tibia and fibula,the anterior tibial A.V and deep peroneal nerve are centered on top of the interosseous membrane and lie in the sagittal plane from 10 to 17.

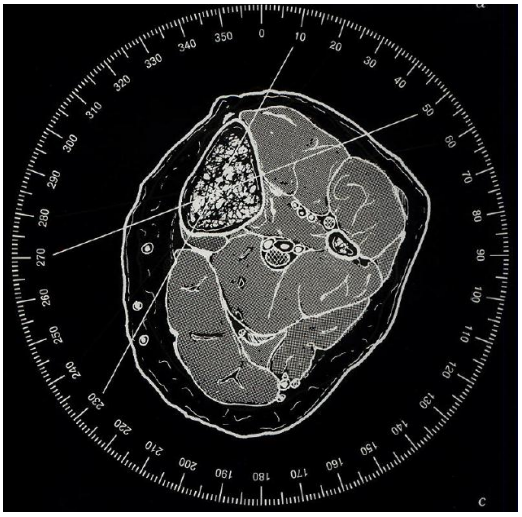


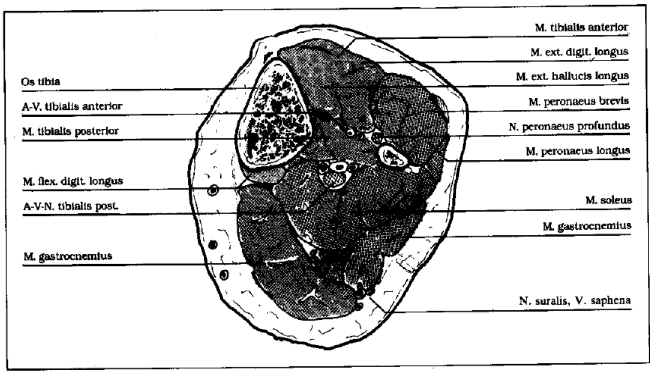


The posterior tibial vessels and tibal nerve are sandwiched between soleus and posterior tibial .M, Only two wires can be applied Transverse wire (280 to 60) Medial phasing fire (20 to 240).

Cut 28

This section is taken “4t” distal to the knee joint The major neurovascular structures proximally, a more central location is noted, the anterior bundle lies anterior to the interosseous membrane. The posterior neurovascular bundle is just dorsal to the posterior tibial muscle, the gastrocnemius has split into its medial and lateral heads.

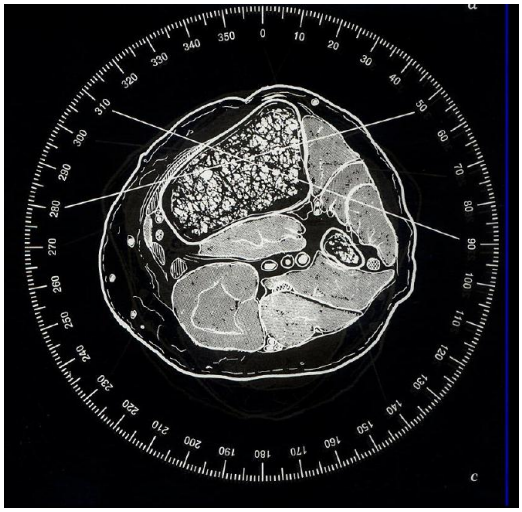


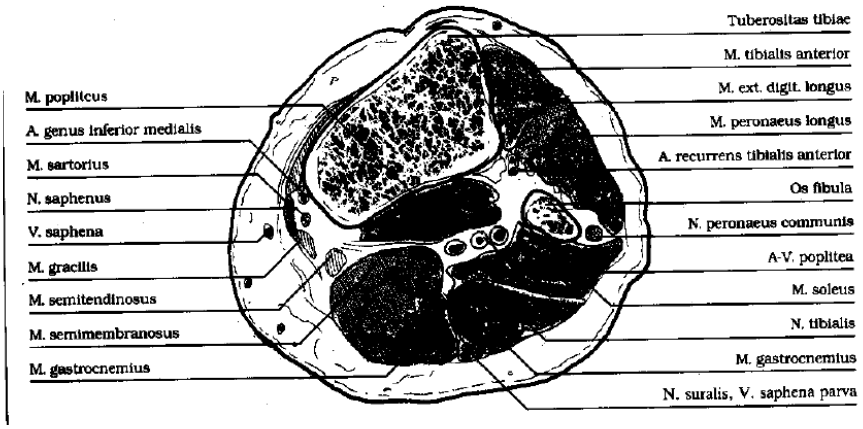


The sural nerve and the lesser saphenous vein run between these two heads, fixation of both bone is prohibited at this level by the numerous vital structures situated between tibia and fibula. Tibial fixation can be carried out in zone of 220 to 60 .the lateral limit of this safe zone is peroneal nerve and posteriorly gastrocnemius

Cut 32

This section is “2t” from the articular surface of the knee and located at the lower portion of the tibial tubercle**.** The saphanenous V.N and medial branch of the inferior geniculate. A run between these muscles of the pes anserine. This section is just above the bifurcation of the popliteal artery



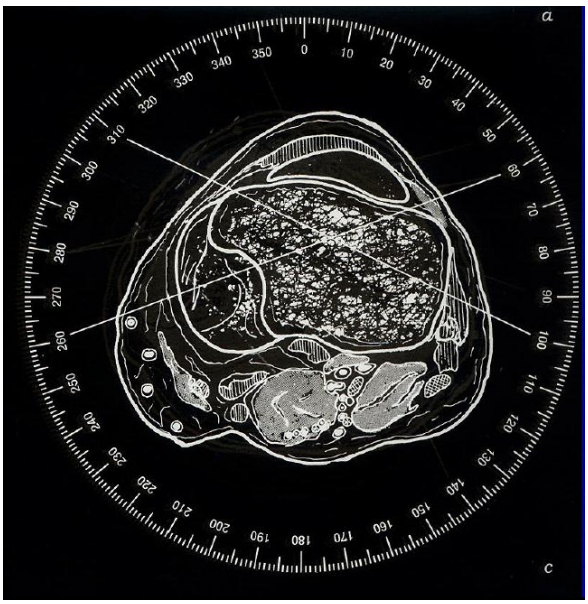


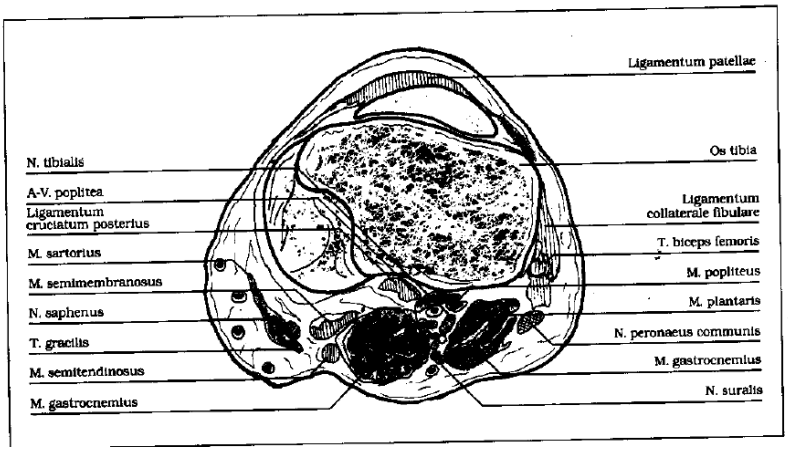
This A.V runs posteriorly with the tibial N, separated from the tibia by the posterior tibial and politeus Muscle. The common peroneal N is located directly lateral to the fibula as it passes from posterior to anterior. The sural nerve remains between the heads of the gastrocnemius.

Tibial fixation can be carried out with wires(50 to 280) and (90 to 310), in addition transfibular wire can be applied (220 to 10).

Cut 36

This cut section is just inferior to the knee joint it transverse medial and lateral tibial plateau, the major neurovascular structures are posterior and slightly lateral with exception of lateral common peroneal nerve and the medial saphenous nerve.





The posterior surface of the tibia provides sites of attachment for the posterior cruciate ligament and popliteus muscle, behind these structure, and in front of the two portion of the gastrocnemius lie the popliteal A. V and tibial N, the surel N continues between the two heads of the gastrocnemius. Medial and lateral access potals can be used, the wire should be placed in optimal divergence (100-360), (60 -260)

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BIBLIOGRAPHY

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ANNEXURE

PROFORMA

"FUNCTIONAL OUTCOME ANALYSIS OF ILIZAROV RING FIXATOR AS DEFINITIVE FIXATION OF OPEN TIBIAL FRACTURES"

Patient's name:

Age:

Sex:

Occupation:

Address:

Contact no:

I.p.no:

Date of injury:

Mode of injury:

Date of admission:

Investigations: Complete Haemogram ,
Blood Urea,Sugar,Sr.Creatinine
Bleeding time and clotting time
Ecg
Chest x-ray
Plain x-ray Ap and lateral view of the Affected limb

Diagnosis: (Using Gustio Anderson classification)

Treatment:

Date of Temporary fixation :

Date of Definitive fixation:

Associated injuries:

Treatment given for Associated injuries:

Time Delay for temporary fixation and debridement:

Time Delay between Definitive fixations:

Implants used:

Intra operative complications:

Post-operative complications:

Post-operative knee mobilisation started at:

Follow up: Evaluated with AP and lateral plain radiographs for evidence of bony union at

Immediate post op
4 weeks post op
8 weeks post op
3 months post op
6 months post op

Functional Assessment using TUCKER'S criteria: Graded as Excellent, Good, Fair and Poor.

ANNEXURE – 2

Tucker's criteria:

- Full knee extension
- Knee flexion >125
- Ankle range of motion >75% of normal
- Limb length discrpancy<1cm
- No angulation >7
- No rotation >7
- Absence of infection

Results:

- Excellent -union with all criteria
- Good -union with one criteria missing
- Fair -union with 2 criteria missing
- Poor -union with 3 criteria missing or nonunion

ANNEXURE – 3

Patient Consent Form

"FUNCTIONAL OUTCOME ANALYSIS OF ILIZAROV RING FIXATOR AS DEFINITIVE FIXATION OF OPEN TIBIAL FRACTURES"

Study detail: Prospective design

Study centre: Govt.Royapettah Hospital, Chennai

Patient's name, age, sex:

Date & place:

Identification number:

I confirm that i have understood the purpose and procedure of the above study. I have the opportunity to ask questions and all my questions and doubts have been answered to my complete satisfaction.

I understand that my participation in the study is voluntary and that i am free to withdraw at any time without giving reason, without my legal rights being affected.

I understand that the ethical committee and the regulatory authorities will not need my permission to look at my health records, both in respect of the current study and any further research that may be conducted in relation to it, even if i withdraw from the study i agree to this access. However i understand that my identity would not be revealed in any information released to third parties or published, unless as required under the law. I agree not to restrict the use of any data or results that arise from this study.

I hereby consent to participate in this study.

I have been clearly explained about the atls protocol and damage control orthopaedics which may be applied as required.

I hereby give permission to undergo complete clinical examination and diagnostic tests including haematological, radiological tests and to undergo the surgical procedure which is individualised based on the fracture pattern.

Patient's name with signature/lt thumb impression

ANNEXURE – 4

நோயாளிஒப்புதல்படிவம்

ஆராய்ச்சியின்விவரம் :

ஆராய்ச்சிமையம் :

நோயாளியின்பெயர் : நோயாளியின்வயது :

பதிவுஎண் :

நோயாளிகீழ்கண்டவற்றுள்கட்டங்களை (✔) செய்யவும்

1. மேற்குறிப்பிட்டுள்ளஆராய்ச்சியின்நோக்கத்தையும்பயனையும்முழுவதுமாகபுரிந்துகொண்டேன். மேலும்எனதுஅனைத்துசந்தேகங்களையும்கேட்டுஅதற்கானவிளக்கங்களையும்தெளிவுபடுத்திக் கொண்டேன். ☐

2. மேலும்இந்தஆராய்ச்சிக்குஎனதுசொந்தவிருப்பத்தின்பேரில்பங்கேற்கிறேன்என்றும், மேலும்எந்தநேரத்திலும்எவ்விதமுன்னறிவிப்புமின்றிஇந்தஆராய்ச்சியிலிருந்துவிலகமுழுமையான உரிமைஉள்ளதையும், இதற்குஎவ்விதசட்டபிணைப்பும்இல்லைஎன்பதையும்அறிவேன். ☐

3. ஆராய்ச்சியாளரோ, ஆராய்ச்சிஉதவியாளரோ, ஆராய்ச்சிஉபயத்தாரோ, ஆராய்ச்சிபேராசிரியரோ, ஒழுங்குநெறிசெயற்குழுஉறுப்பினர்களோஎப்போதுவேண்டுமானாலும்எனதுஅனுமதியின்றிஎனது உள்நோயாளிபதிவுகளைஇந்தஆராய்ச்சிக்காகவோஅல்லதுஎதிர்காலபிறஆராய்ச்சிகளுக்காகவோபயன் படுத்திக்கொள்ளலாம்என்றும், மேலும்இந்தநிபந்தனைநான்இவ்வாரய்ச்சியிலிருந்துவிலகினாலும்தகும்என்றும்ஒப்புக்கொள்கிறேன் ஆயினும்எனதுஅடையாளம்சம்பந்தப்பட்டஎந்தபதிவுகளும் (சட்டபூர்வமானதேவைகள்தவிர) வெளியிடப்படமாட்டாதுஎன்றஉறுதிமொழியின்பெயரில்இந்தஆராய்ச்சியிலிருந்துகிடைக்கப்பெறும் முடிவுகளைவெளியிடமறுப்புதெறிவிக்கமாட்டேன்என்றுஉறுதியளிக்கின்றேன். ☐

4. இந்தஆராய்ச்சிக்குநான்முழுமனதுடன்சம்மதிக்கின்றேன்என்றும்மேலும்ஆராய்ச்சிக்குழுவினர்எனக்கு அளிக்கும்அறிவுரைகளைதவறாதுபின்பற்றுவேன்என்றும்இந்தஆராய்ச்சிகாலம்முழுவதும்எனதுஉடல் நிலையில்ஏதேனும்மாற்றமோஅல்லதுஎதிர்பாராதபாதகமானவிளைவோஎற்படுமாயின்உடனடியாக ஆராய்ச்சிகுழுவினரைஅணுகுவேன்என்றும்உறுதியளிக்கின்றேன். ☐

5. இந்தஆராய்ச்சிக்குத்தேவைப்படும்அனைத்துமருத்துவப்பரிசோதனைகளுக்கும்ஒத்துழைப்புதருவேன் என்றுஉறுதியளிக்கின்றேன். ☐

6. இந்தஆராய்ச்சிக்குயாருடையவற்புருத்தலுமின்றிஎனதுசொந்தவிருப்பத்தின்பேரிலும்சுயஅறிவுடனும் முழுமனதுடனும்சம்மத்திக்கின்றேன்என்றுஇதன்மூலம்ஒப்புக்கொள்கிறேன். ☐

நோயாளியின்கையொப்பம் / பெருவிரல்கைரேகை ஆராய்ச்சியாளரின்கையொப்பம்

இடம்: தேதி:

ANNEXURE – 5

INSTITUTIONAL ETHICAL COMMITTEE
GOVT. KILPAUK MEDICAL COLLEGE,
CHENNAI-10
Protocol ID. No.07/04/2015 Meeting held on 09/04/2015
CERTIFICATE OF APPROVAL

The Institutional Ethical Committee of Govt. Kilpauk Medical College, Chennai reviewed and discussed the application for approval "Functional outcome analysis of Ilizarov ring fixator as definitive fixation of open tibial fractures"– For Dissertation Purpose submitted by Dr.Duraisamy Ezhilmaran, Post Graduate in MS (Ortho), Govt. Kilpauk Medical College / GRH, Chennai.

The Proposal is APPROVED.

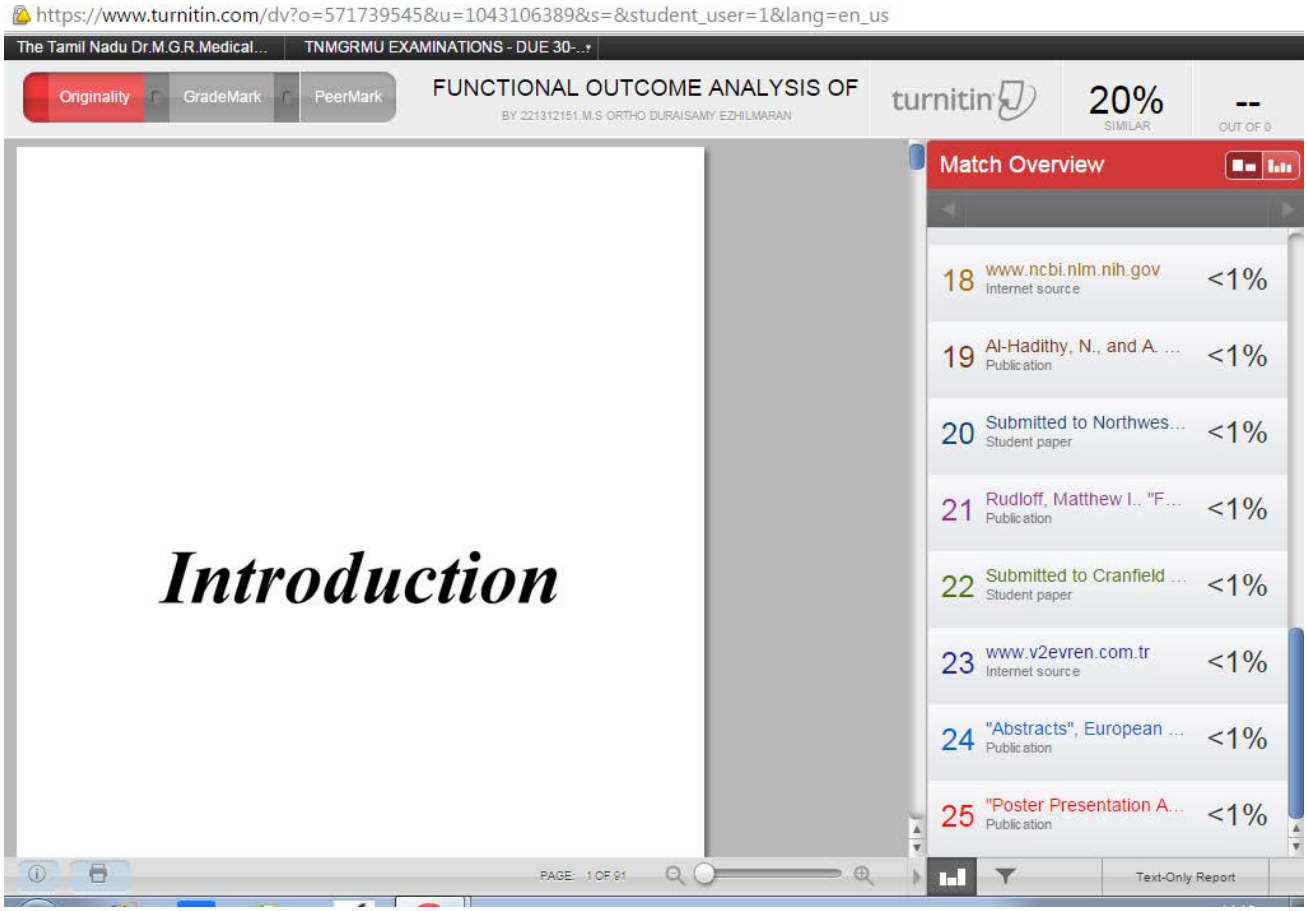
The Institutional Ethical Committee expects to be informed about the progress of the study any Adverse Drug Reaction Occurring in the Course of the study any change in the protocol and patient information /informed consent and asks to be provided a copy of the final report.

10/6/15

CHAIRMAN,
Ethical Committee
Govt. Kilpauk Medical College, Chennai

GOVT. KILPAUK MEDICAL COLLEGE
10 JUN 2015
Kilpauk, Chennai-10.

10/6/15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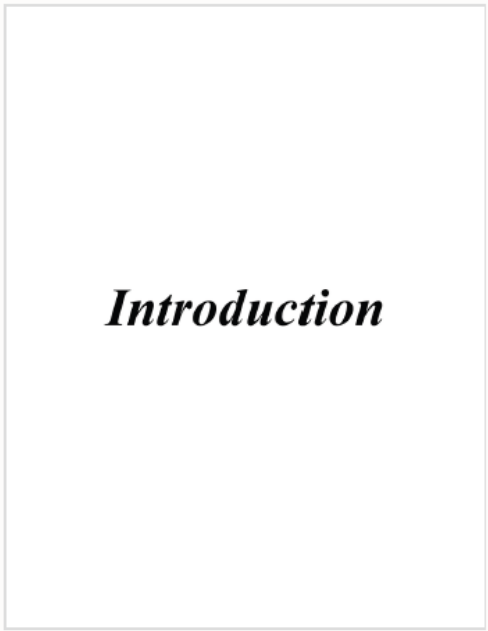

Master chart

Case	Name	Age	Sex	Mode of injury	R/L	Ao fracture pattern	G.a Classification	Time to arrival	Time to ao fixation	IRF	sec. debridement	Duration on ao	Duration on IRF	Duration on functional cast	Fracture union	Complications									Functional outcome
																Pin tract infection	Pain	Delay Union	Non Union	Limb length-shortening	Deformity	Equinus	Movement		Additional procedure	
																							Knee	Ankle		
1	Amsaveni	45	F	RTA	Left	42A1	Grade 3a	6 Hrs	Not done	3d	Not done	Not done	6 Months	1 month	5month	Yes	Yes	Nil	Nil	Nil	Nil	Nil	Full	full	Not done	Excellent
2	Arumugam	49	M	RTA	Right	42A2	Grade 3a	4 HRS	Done	3d	Done	3 days	7 Month	1month	6th month	Yes	No	Yes	Nil	Nil	Nil	Nil	Full	Full	BM injection	Excellent
3	Boominathan	40	M	RTA	Right	42A2	Grade 3 a	5hrs	Done	3d	Done	3days	6months	1 moth	5th month	Yes	No	Nil	Nil	Nil	Nil	Nil	Full	Full	Nil	Excellent
4	Diwakar	22	M	RTA	Right	43A3	Grade3b	8hrs	Done	5d	Done	5 days	5months	1 month	5th month	Yes	No	Nil	Nil	Nil	Nil	Nil	Full	Full	SSG	Excellent
5	Duraivel	32	M	RTA	Right	42B1	Grade 3a	6 HRS	Done	2d	Done	2 days	8 Months	1 month	7th month	No	YES	Yes	NIL	Yes	NIL	Yes	Full	Full	BM injection	Fair
6	Ismail	40	M	RTA	Left	43A3	Grade3a	24 hrs	Done	5d	Done	5 days	8months	2 month	6th month	Yes	No	Yes	Nil	Nil	Nil	Nil	Full	Full	bone graft	Good
7	Johnson	35	M	RTA	Right	42B2	Grade 3a	6hrs	Done	3d	Done	3 days	7months	2 months	5 months	No	Yes	Yes	Yes	Nil	Nil	Nil	Full	Full	Bone graft with ssg	Good
8	Kanniammal	50	F	RTA	Left	42B3	Grade3a	4 hrs	Done	5d	Done	5 days	7months	1month	6months	No	Nil	Nil	Nil	yes	Nil	Nil	Neal full	Near full	flap cover	Fair
9	Karthick	35	M	RTA	Right	42B2	Grade3a	6 hrs	Done	3d	Done	3 days	6 months	15 days	5th month	Yes	Nil	Nil	Nil	Nil	Nil	Nil	Full	Full	Nil	Good
10	Lakshmanan	55	M	Fall from height	Right	42B3	Grade 3b	7hrs	Done	5 d	Done	5 day	6month	1month	5thmonth	No	Yes	Nil	Nil	Nil	Nil	nil	Full	Full	Flap cover	Good
11	Madhuvanan	35	M	RTA	Right	42C1	Grade2	3hrs	Notdone	3d	Notdone	Not done	5month	1 month	6th month	Yes	Yes	Nil	Nil	Nil	Nil	nil	Full	Full	Nil	Excellent
12	Madurai	65	M	RTA	Right	42C2	Grade 3b	5hrs	Done	4 d	Done	4 days	9 month	2 month	7th month	Yes	Yes	Nil	Nil	Nil	Nil	Nil	Full	Full	Ssg and flap cover	Good
13	Mayakrishnan	25	M	RTA	Left	42C2	Grade 2	4hrs	Done	3 d	Done	3 days	6 month	1month	5thmonth	No	Nil	Nil	Nil	Nil	Nil	Nil	Full	Full	Nil	Good
14	Md.ali	35	M	Fall from height	Left	42C2	Grade 1	2hrs	Not done	4d	Not done	Not done	7 month	1 month	4th month	No	Nil	Nil	Nil	Nil	Nil	Nil	Near full	Near full	Nil	Fair
15	Narayanan	22	M	RTA	Right	42C3	Grade 3b	2hrs	Done	2 d	Not done	Nil	6 month	1 month	5th month	Yes	yes	Nil	Nil	Nil	Nil	Nil	Full	Full	Nil	Fair
16	Rajamanikandan	32	M	RTA	Right	42C3	Grade 2	3 hrs	Not done	2 d	Not done	Not done	6 month	1 month	5 th month	No	Nil	Nil	Nil	Nil	Nil	Nil	Full	Full	Nil	Fair
17	Ramakrishnan	38	M	RTA	Right	43C3	Grade 3a	3hrs	Done	3 d	Done	3 days	7 month	1 month	6th month	Yes	nil	Nil	Nil	Nil	Nil	Nil	Full	Full	Ssg	Fair
18	Sakthivel	35	M	RTA	Right	42C3	Grade 3a	5hrs	Done	4 d	Done	4 days	6 month	1 month	5th month	No	nil	Nil	Nil	Nil	Nil	Nil	Full	Full	Nil	Good
19	Sanguabala	40	M	RTA	Right	43C2	Grade 2	4hrs	Not done	5d	Not done	5 days	6 month	15 days	5th month	No	yes	Nil	Nil	Nil	Nil	Nil	Full	Full	Nil	Good
20	Sekar	32	M	RTA	Right	43C3	Grade 3b	2 hrs	Done	3 d	Done	3 days	7 month	1 month	6th month	No	yes	Nil	Nil	Nil	Nil	Nil	Full	Full	Flap cover	Poor
21	Siva	24	M	RTA	Left	43C2	Grade 3a	1 hrs	Done	3d	Done	3 days	12 month	1 month	7th month	Yes	yes	Nil	Nil	Nil	Nil	Nil	Full	Full	Bone transport corticotomy	Good
22	karthikeyan	35	M	RTA	Left	43C1	Grade 2	2 hrs	Not done	3 d	Not done	Not done	6 month	1 month	5th month	Yes	yes	Nil	Nil	Nil	Nil	Nil	Full	Full	Nil	Fair
23	Mohamed	55	M	RTA	Right	43B1	Grade 2	6 hrs	Not done	3 d	Not done	3 days	6 month	1 month	5th month	Yes	yes	Nil	Nil	Nil	Nil	Nil	Full	Full	Nil	Poor
24	Pasupathy	60	M	RTA	Right	42C2	Grade 3a	3 hrs	Done	2 d	Done	2 days	7 month	1 month	6th month	Yes	yes	Nil	Nil	Nil	Nil	Nil	Full	Full	Nil	Poor
25	Lakshmi	48	M	RTA	Right	42C2	Grade3a	2hrs	Done	2 d	Not done	2 days	8 month	1 month	7th month	Yes	il	Nil	nil	Nil	Nil	Nil	Full	Full	Nil	Fair